VOLUME 17, NO. 12
DECEMBER 1985

1

THE SHOCK AND VIBRATION DIGEST

A PUBLICATION OF
THE SHOCK AND VIBRATION
INFORMATION CENTER
NAVAL RESEARCH LABORATORY
WASHINGTON, D.C.

OFFICE OF
THE UNOER
SECRETARY
OF DEFENSE
FOR RESEARCH
AND
ENGINEERING

A publication of

THE SHOCK AND VIBRATION INFORMATION CENTER

Code 5804, Naval Research Laboratory
Washington, D.C. 20375-5000
(202) 767-2220

THE SHOCK AND VIBRATION DIGEST

Volume 17, No. 12
December 1985

The **Shock and Vibration Digest** is a monthly publication of the Shock and Vibration Information Center. The goal of the Digest is to provide efficient transfer of sound, shock, and vibration technology among researchers and practicing engineers. Subjective and objective analyses of the literature are provided along with news and editorial material. News items and articles to be considered for publication should be submitted to:

Dr. R.L. Eshleman
Vibration Institute
Suite 206, 101 West 55th Street
Clarendon Hills, Illinois 60514
(312) 654-2254

Copies of articles abstracted are not available from the Shock and Vibration Information Center (except for those generated by SVIC). Inquiries should be directed to library resources, authors, or the original publishers.

This periodical is for sale on subscription at an annual rate of $200.00. For foreign subscribers, there is an additional 25 percent charge for overseas delivery on both regular subscriptions and back issues. Subscriptions are accepted for the calendar year, beginning with the January issue. Back issues are available -- Volumes 11 through 16 -- for $40.00. Orders may be forwarded at any time to SVIC, Code 5804, Naval Research Laboratory, Washington, D.C. 20375-5000. The Secretary of the Navy has determined that this publication is necessary in the transaction of business required by law of the Department of the Navy. Funds for printing of this publication have been approved by the Navy Publications and Printing Policy Committee.

SVIC NOTES

Subject/Author Indexes for Annual Technical Meetings

Keeping track of the information received at annual technical meetings is a problem for attendees. If, like me, you have attended one or two meetings for several years, you probably have a five to ten year set of proceedings sitting on your bookshelf. By now, you find it difficult to find particular articles, especially the older ones. Others in your office find it even more difficult to find the same information because they didn't even go to the meeting. The proceedings gather dust and the return on the investment made by your organization to send you to the meeting and buy the proceedings becomes nil.

All of these problems would be solved if meeting organizers would, at regular intervals, publish a subject/author index of their proceedings. Such an index is a great time saver and allows an organization to extract the maximum benefit from the proceedings.

There are several key principles to follow when creating an index: (1) keep it simple, (2) design it to serve the needs of the meeting attendee, (3) base the subject index primarily on the titles of the individual meeting sessions followed by the most significant subject terms in the titles of the papers. The first principle, keeping the index simple, increases the likelihood that the index will be produced at regular intervals because production will be easier. The second and third principles are interlocked and logical. Ask the question, "in what way does the average person recall what they learned at a meeting?" Most likely they will remember the overall title of a session they actually attended such as PYROTECHNIC SHOCK or MODAL TESTING. They also might remember one or more major subjects from the title of a paper they heard or even the name of the author. It is logical then to create an index according to the above principles two and three, because it fits well with the way human memory operates.

If there isn't an index to your favorite set of proceedings, take steps to have one created; better yet, get on a working group to create one yourself. The best solution, of course, would be to have the meeting planners themselves put the index together.

JGS

EDITORS RATTLE SPACE

THE ENGINEER AND SOCIETY

In a recent article in Science magazine* an editorial, "The Status of Engineering", dealt with the role of the engineer in modern society. In essence Baker concludes that unless there is more media awareness and recognition of the engineering profession the standard of living in USA will decline. While this may seem like a naive and sweeping conclusion, it is not without basis. The conclusion is based on the premise that without recognition, encouragement, and reward a profession does not attract good people. Without talented persons we will not be able to design the complex systems required to maintain the status quo -- much less move ahead. Apparently some countries other than USA have been able to overcome this problem.

In my opinion, the signs of this decline are present. Our widening trade deficit means more than a lack of management. Much publicity has been given to Japanese style management; however, little significance is given to efficient production methods including the use of robots. The facts of life indicate that increased efficiency and productivity is necessary. Yet few of our schools remotely relate to production engineering. I do not fault the schools for this problem -- the motivation has to come from society. This leads me into another sign of decline. One of the most valuable resources of any society is its schools and universities. Today our university system is in jeopardy. Good people are not being properly recognized or rewarded. The result will be inferior training for future engineers. This means less innovation and ability to develop the complex systems required to function in the society of tomorrow. The fact that few engineers are taking graduate training and that talented professors are leaving the university because of financial hardship are adequate signs of decline. The design of the complex interdisciplinary systems of tomorrow will require more training and better physical understanding than ever required in our present space age.

Baker comments that the public is more aware of scientists and science than of engineers. I believe this is only true for the case of persons involved in the life sciences. The media deal with the life sciences quite well -- largely because the average person in society can relate to this area. I don't think the media deals any better with physical scientists than engineers. It is a fact that the average person in society is unaware of what an engineer does -- nor does he or she care. To the public, the engineer is some mystical genius who uses a lot of math to do his or her job. In recent years I have been increasingly aware of the life science orientation of educational programs on television. The little exposure I have had in other countries showed this was not true. Furthermore I cannot explain why the media have neglected physical systems and all that is associated with them. Even the space shuttle did not help the situation. Perhaps it is because engineers and scientists are satisfied to quietly do their job. Perhaps it would be good for both them and society if they were more vocal. The successful people that I have known were successful not only because they were talented but also because they let people know of their accomplishments.

In my opinion, society is going to have to become more aware of engineers and what they do if we are to increase recognition and reward -- those factors necessary to increase the productivity, ability, and ingenuity required to maintain and increase our standard of living. Only the media have the power to accomplish this task. Perhaps engineers will have to be more vocal and educate the media on these facts of life.

R.L.E.

*Baker, D. Kenneth, "The Status of Engineering," 230 (4721), 4 October 1985, p 13.

ACOUSTIC EMISSIONS FROM WIRE AND SYNTHETIC ROPES

P.A.A. Laura*

Abstract. The rupture of mechanical cables used in towing operations, remote control of equipment, and salvage operations can result in loss of both life and equipment. Accordingly, reliable and simple methods to assess the structural integrity of mechanical cables are of utmost importance. The present paper is a brief review of applications of the acoustic emission method from the point of view of the nondestructive evaluation of wire and synthetic ropes and monitoring their mechanical status while in operation.

Cables and cable systems are extremely important in ocean and coastal engineering; e.g., mooring buoys and vessels, towing and trawling operations, supporting underwater instruments. Such systems also constitute essential structural elements in tension leg platforms and suspended bridges [1].

As stated by Harris and Dunegan [2] "the extensive use of wire rope in a wide variety of applications, and the difficulty of nondestructively evaluating the integrity of rope by conventional techniques, has led to an increased interest in the acoustic emission characterization of such components." Similar considerations are valid in the case of synthetic ropes. Acoustic emission techniques have been used in applications ranging from nuclear reactors and space vehicles technology to materials research.

Acoustic emission phenomena begin when a crack propagates in a stressed solid. A portion of the strain energy stored in the body is released and a compression wave is propagated. The resulting particle motions can be picked up by transducers placed at the surface of the solid. Acoustic emission techniques are very sensitive to wire or fiber breakage and are, therefore, well suited for monitoring the structural status of wire [3] or synthetic rope [4] and for performing nondestructive evaluation.

ACOUSTIC EMISSIONS IN THE CASE OF WIRE ROPE

A brief review of research into failure mechanisms of cable ropes and the acoustic emission signatures of the various cables has been published [5]. Early uses of the acoustic emission method to detect deterioration of a cable prior to complete failure were motivated by the loss of the deep submersible ALVIN [3]. These early investigations showed that clearly audible stress waves were emitted at approximately 95 percent of the maximum load allowed.

Harris and Dunegan [2] extended early investigations and performed cyclic loading experiments and rising load tests. They obtained several important results:

> acoustic emission techniques can be used to measure the number of wires that break during a given loading of a cable
>
> faulty cables can be easily distinguished by the acoustic emission method
>
> continuous acoustic monitoring of fatigue cycling of cables is easily accomplished and provides ample warning of impending fatigue failure

From the point of view of developing a realistic, operational system the most important contribution was work performed at the Defence Research Establishment between 1976 and 1979 [6]. The research program has resulted in a thorough understanding of the acoustic response from an AN/SQS 505 VDS (variable depth sonar) tow cable and use of that information to safeguard a towed body from loss due to fatigue failure of the cable. An impressive amount of experimental work was performed that made it possible to design a

***Director and Research Scientist, Institute of Applied Mechanics, Puerto Belgrano Naval Base, 8111 - Argentina**

cable monitoring system. The transducer and preamplifier are mounted at the point of most probable failure of the VDS cable: the sea-end cable termination.

ACOUSTIC EMISSIONS IN THE CASE OF SYNTHETIC ROPE

It has been stated [7] that "the rupture of a synthetic fiber rope (or line in marine use) under stress is often associated with an explosive snapback."

"Any object or individual in the path of the rope snapback may suffer serious damage or injury. In spite of a distinct need for nondestructive evaluation (NDE) procedures for the structural integrity assessment of new and used synthetic lines, NDE procedures are currently limited to visual examinations."

Vanderveldt and Tran [4] were the first researchers to apply the stress wave emission monitoring method to the study of synthetic ropes. They examined three different types of braided synthetic rope: nylon cover over nylon core, polyester cover over polypropylene core, and nylon cover over polypropylene core. An accelerometer was used to detect stress waves in the procedure utilized [3].

Vanderveldt and Tran [4] showed that an increase of at least an order of magnitude in the slope of the curve of the number of stress wave emissions vs the applied load is a good indicator of impending catastrophic failure. No significant differences in stress wave emission characteristics were observed for the three types of synthetic ropes considered [4].

Acoustic emissions of synthetic ropes subjected to loading have been studied by other researchers. Important results were obtained by Williams and Lee [7]. Recently the NDE technique of acoustic-ultrasonic testing has been applied to nylon ropes [8].

The NDE technique of acoustic-ultrasonic testing involves introduction of an ultrasonic pulse into a structural system via a transmitting transducer. The dynamic disturbance is detected by a receiving transducer mounted on the same face of the structure. The result is generally defined as the stress wave factor (SWF). The SWF is evaluated as the number of threshold crossings of the ring-down oscillations in the output signal from the receiving transducer. This parameter indicates the relative efficiency of energy transmission at the receiver frequency [8].

Acoustic-ultrasonic NDE have been conducted on new dry Samson double-braided 2-in. nylon rope [8]. Stress wave factors were determined at various tensions for undamaged, core cut, core removed, and cover cut rope samples. This excellent study shows that there are characteristic SWF vs load properties for undamaged and damaged ropes.

However, the SWF characteristics are caused by complex mechanisms. Two variables with considerable, competing effects are the transducer-rope contact area and the rope compaction coupling between all the structural members: fibers, yarns, core, and cover. As stated by the investigators [8], "the SWF characteristics are due to rather complex mechanisms. Thus, applications of the stress wave factor in the NDE of structures in general, and synthetic fiber ropes in particular, should be coupled with adequate SWF modeling to achieve the maximum capability and the proper interpretation of the results of this test technique."

REFERENCES

1. Lo, A. and Leonard, J.W., "Dynamic Analysis of Underwater Cables," ASCE J. Engrg. Mech. Div., 108, pp 605-621 (1982).

2. Harris, D.O. and Dunegan, H.L., "Acoustic Emission Testing of Wire Rope," Matls. Eval., 15, pp 1-6 (1974).

3. Laura, P.A.A., Vanderveldt, H.H., and Gaffney, P., "Mechanical Behavior of Stranded Wire Rope and Feasibility of Detection of Cable Failure," Marine Tech. Soc. J., 4, pp 19-32 (1970).

4. Vanderveldt, H.H. and Tran, Q., "Acoustic Emissions from Synthetic Rope," Naval Engrs. J., 83, pp 65-68 (1971).

5. Laura, P.A.A. and Matthews, J.R., "Monitoring the Status of a Mechanical Cable While in Operation by Means of the Acoustic Emission Method," Ocean Engrg. (1985).

6. Matthews, J.R. and Black, M.R., "Acoustic Emission Signature at Variable Depth Sonar Tow Cable," Intl. Advances Non Destruc. Test., 7, pp 181-214 (1981).

7. Williams, J.H. and Lee, S.S., "Acoustic Emission Rupture Load Characterizations of Double-Braided Nylon," Marine Tech., 19, pp 268-271 (1982).

8. Williams, J.H., Hainsworth, J., and Lee, S.S., "Acoustic-Ultrasonic Nondestructive Evaluation of Double Braided Nylon Ropes Using the Stress Wave Factor," Fibre Sci. Tech., 21, pp 169-180 (1984).

LITERATURE REVIEW: survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four reviews each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the **DIGEST** reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

RECENT RESEARCH ON TURBULENT FLOW NOISE MECHANISMS

D.F. Long* and R.E.A. Arndt*

Abstract. This article is concerned with the pressure field generated by large-scale coherent motions in turbulent flows. A general decomposition is discussed that evaluates the magnitude of the coherence in an unbiased way. This tool is described in terms of two flows of current interest, jets and boundary layers.

As with most disciplines, the experimental techniques used in turbulence research follow from what is believed to be the physics of the problem. Turbulence was once thought to be a random and chaotic motion of parcels of fluid riding upon a given mean flow pattern. Previous measurements reflect this view. The structure of a turbulent boundary layer, for instance, was thought to be describable in terms of regions of the mean velocity profile. Such terms as sublayer, buffer layer, logarithmic region, and wake region are typical [1].

There has been an increasing awareness that the fluctuating component may not be totally random. Flow visualization studies indicate that, in addition to the mean and random components of the motion, there may be a third term, which is known as a quasi-coherent motion. Spurred by visualization in boundary layers [2, 3] and in jets and shear layers [4-7] investigators began to study whether the presence of this quasi-coherent motion played a major role in turbulence dynamics. Such words as bursts, sweeps, and streaks were used to describe the boundary layer structure in place of words based on mean velocity profile. A similar trend was noted in studies of jets and shear layers.

Some investigators [8, 9] then began to question the role played by these coherent structures in the noise radiation process, mostly in jets and to a limited degree in boundary layers. It was noticed that these large-scale structures were readily observable at Reynolds numbers based on jet diameter less than 10^5 but disappeared at higher Reynolds number. Curiously, changes in radiated noise also occurred, depending on whether the Reynolds number was less than or greater than 10^5 [10, 11]. Some investigators thought that the large scales might still be present but were masked by the high level of small-scale turbulence [8].

Any of three possible mechanisms might actually produce the noise. One is the traditional view that the turbulence is composed of a large number of random turbulent eddies acting independently and that the noise is produced by collisions and vibrations of small-scale eddies [12].

A second possibility is that the large-scale structure produces noise directly. An example is a jet excited by a pure tone. At a very specific condition [13, 14] the jet can be made to produce discrete tones in the noise spectrum that can be directly related to the large structure. It is thought that successive vortex pairings cause a fluctuating stress that acts as a noise source and produces the tones. It is not known if this mechanism occurs in unexcited or natural jets to any significant degree.

It is the third possibility that we feel is most plausible for natural jets and possibly boundary layers: the large-scale structure acts as a modulator of the smaller scales that actually produce the noise. The large scales may thus be making the process either more or less efficient. Obviously, this concept is very difficult to prove conclusively, but there is some evidence to support it [8, 9].

Traditional jet noise experiments [15, 16] were conducted assuming that the first possibility was the correct mechanism. The

*St. Anthony Falls Hydraulic Laboratory, University of Minnesota, Minneapolis, MN 55414

experiments were generally designed to verify the theory [12, 17] through measurements of intensity, directivity, and spectral density. The general features were verified; subtle discrepancies were explained away as due to scattering and interference effects. In view of the possible presence of coherent structures, these subleties should be reexamined.

Far-field measurements are doomed to failure in determining the nature of the source in part because of the extremely small amount of total jet power that is radiated as noise. The acoustic radiation efficiency of a subsonic jet is on the order of 10^{-4} times the Mach number to the fifth power [15]; the noise source mechanism is therefore associated with a very small fraction of the local turbulence energy. It seems likely then that the radiated noise does not result from gross features of the turbulence but from a much more subtle interaction. Therefore, attempts at a correlation between far-field noise and local turbulence appear tenuous at best.

If measurement procedures are as unbiased as possible, subjectivity is restricted to interpretation of results. If a procedure is applied to many similar experiments, subtle interactions and differences may provide a clue to the radiated noise problem. At present, however, every experiment is conducted differently and, due to individual bias, not only the results but also the measurement procedures are subject to interpretation. Two similar experiments can appear to show opposite results due to the measurement techniques employed [18, 19].

Two experimental situations in which radiated noise is of concern are considered below: jet noise (the most obvious example) and boundary layer noise. A proposed procedure is to decompose the fluctuations associated with the turbulence into orthogonal components; i.e., the so-called Karhunen-Loeve, or K-L, expansion. These components are related to the structure of the turbulence and discussed in terms of possible noise generators. Homogeneous and stationary random variables are also briefly discussed.

STATIONARY AND HOMOGENEOUS PROCESSES

The significance and usefulness of the K-L expansion rests in its use in nonhomogeneous and nonstationary situations. Stationarity traditionally refers to a time signal; homogeneity refers to a spatial structure. From an analytic point of view they mean the same thing; i.e., only relative distances are important in terms of statistics. As far as the time signal is concerned, the random signal under consideration has the same general character at present as it will at a later time; the mean level, rms level, and higher order moments are invariant. As far as spatial variables are concerned, the correlations and length scales are invariant from point to point.

The alternative to either situation is that the signal is either nonhomogeneous or nonstationary. A few specific examples illustrate the point. For instance, the acceleration of a body immersed in a fluid or the start-up of a wind tunnel are examples of a nonstationary process; the motion of a body at constant velocity through a fluid or the continuous operation of a wind tunnel are stationary.

Note that an experiment could be classified either as stationary or nonstationary depending on the desired result. A cavitation experiment is an example. The overall situation is stationary; that is, the character of the output signal is the same at any instant. On the other hand, the output of a single cavitation event is nonstationary. There is no noise before the event. The event causes an intense pop that is followed by a few oscillations due to the bubble rebounding. The character of this event is not the same at any instant. A single event is nonstationary but the whole experiment is stationary.

Spatial variables can be treated similarly. They are either homogeneous or nonhomogeneous. However, because space is described by a vector comprised of three perpendicular directions, it is direction that is homogeneous or nonhomogeneous.

A simple example is two-dimensional shear layer. The flows have been studied extensively in laboratory experiments because

they show all the features of more complex flows. The three independent directions are denoted in the usual sense by x, y, and z; the orientation of the mixing layer is shown in Figure 1.

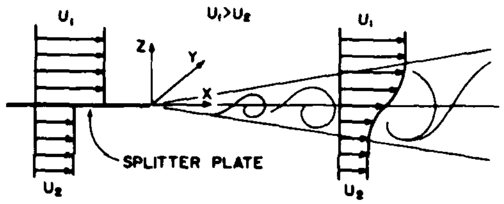

Figure 1. Mixing Layer Orientation

The transverse direction y is homogeneous because the flow variables should have the same general character from one point to the next. The existence of end plates or a finite width channel must be neglected; only the interior portion can be considered homogeneous. For a large aspect ratio (width/height > 10) this is a satisfactory approximation.

The vertical direction is strongly nonhomogeneous; the flow properties change significantly from one point to the next. This is easily seen by noting the change in the rms fluctuation level across the layer. The center has a high intensity that dies off almost to zero in the two free streams. Other properties and moments also change, but the vertical direction can be defined as nonhomogeneous.

The streamwise direction is also nonhomogeneous; small-scale eddies occur close to the origin of the mixing layer, and larger scales occur further downstream. Each eddy scale exists for only a limited spatial range.

Even the simplest turbulent flows are nonhomogeneous in at least one direction. In fact, three-dimensional homogeneous turbulence is difficult to find except in the limited context of grid turbulence in a wind tunnel. Nonhomogeneity is the rule rather than the exception.

THE ORTHOGONAL DECOMPOSITION — AN UNBIASED APPROACH

The orthogonal decomposition, or Karhunen-Loeve (K-L) expansion, is a technique for studying the spectral content of a nonhomogeneous direction or a nonstationary process. The objective is to decompose the original signal into its component eigenvalues and eigenfunctions. This is similar to Fourier analysis of a signal, but Fourier methods are restricted to stationary or homogeneous processes. Both methods seek an energy content (eigenvalue) and a characteristic form (eigenfunction). The difference is that in Fourier analysis the forms of the eigenfunction are known; they are the harmonic functions. It can be shown that the K-L expansion reduces to the harmonic decomposition if the independent variable is homogeneous.

Even though the K-L expansion is a generalization of Fourier methods, it is not widely used in turbulence analysis. The reason is partly that the technique was only recently introduced to the turbulence community [20] and partly because of the enormous amount of input data required. A nonhomogeneous variable requires an amount of input data equivalent to that of a homogeneous variable squared. If an adequate description of a homogeneous variable can be obtained from ten measurements, a similar description for a nonhomogeneous will require 100 measurements. The measurement that is typically necessary is the cross-spectral density between two measurement probes.

The technique centers around the eigenvalue problem

(1)

$$R(x,x';y,y';\ldots;t,t')$$

$$v^{(n)}(x',y',\ldots t')dx',dy',\ldots dt'$$

$$= |\lambda^2|^{(n)} v^{(n)}(x,y,\ldots,t)$$

This problem is a result of decomposing the original signal into its component eigenvalues and eigenfunctions. For instance, for a scalar random signal P

(2)

$$P(x,y,\ldots,t) = \sum_{n=1}^{\infty} \lambda^{(n)} \xi_n V^{(n)}(x,y,\ldots t)$$

The $V^{(n)}$ form an orthonormal basis and the eigenvalues contain the amplitude information. This can be developed into equation (1) where $R(x,x';\ldots)$ is the covariance of P [21]. Formally this covariance is the expected value of P over all lags,

(3)

$$R(x,x';y,y';\ldots 't,t')$$

$$= E\{P(x,y,t),P(x',y',t')\}$$

Without too much difficulty, it can be extended to a vector field U_i instead of the scalar P. The covariance becomes a tensor valued function $R_{ij}(x\ldots)$. For the present, scalar functions only are used for simplicity.

Equation (1) can be interpreted independently for each independent variable. Because time is a stationary variable in most situations, it can be treated by a Fourier transform. The Fourier transform of equation (1) can be written as

(4)

$$S(x,x';y,y';\ldots;\omega)V^{(n)}(x',y',\ldots;\omega)$$

$$= |\lambda^2|^{(n)}V^{(n)}(x,y,\ldots;\omega)$$

S is the cross-spectral density function between two measurement locations and can be determined by standard methods. The resulting eigenvalues and eigenvectors* are interpreted for each frequency component. This process can be repeated for each homogeneous direction. The resulting matrix equation need only be solved for the nonhomogeneous directions.

The solution to equation (4) is easily obtained by the power method. The power method, which is discussed in most texts on numerical methods, is an iterative scheme in which eigenvalues and eigenvectors are produced in order of importance. After a solution is obtained, the eigenvalues and eigenvectors are the complete spectral representation of the problem. They can be interpreted in much the same fashion as a spectral density.

An alternative to harmonic decomposition for stationary variables is the shot-noise decomposition. This technique is useful for obtaining information about time-dependent qualities of flow. It can be incorporated with the orthogonal decomposition into a valuable method that allows a quantitative measure of coherent structures in turbulent flows [20].

The shot-effect was developed for studying the statistics of vacuum tube noise when a pulse is emitted every time an electron reaches the anode [22]. It defines the statistical variation of a sequence of pulses with constant amplitude, a well-defined shape, and random arrival times at the anode. Regardless of how well the pulses are defined, the probability distribution of the signal will be normal because of the random arrival times. The randomness of arrival time implies that the individual pulses are independent of one another; the central limit theorem guarantees the normality of the distribution. The moments of the distribution associated with the pulse are indeterminant from standard statistical measurements. However, the measured spectrum is the Fourier transform of an individual pulse. The characteristic shape of the individual pulse can be reconstructed from the inverse Fourier transform of the measured spectrum. The full complex spectrum is necessary, however; the amplitude or power spectrum is not sufficient. The full complex spectrum is easily obtained from the results of the orthogonal decomposition. The individual pulse shape thus determined is called a characteristic event.

A brief development [20] is now considered for a scalar field $P(x,t)$; x represents nonhomogeneous direction and t represents stationary time.

It is supposed that the signal can be decomposed as

(5)

$$P(x,t) = f(x,t)*g(x,t)$$

***In theory, the covariance and the eigenfunctions are continuous functions; in practice, discrete probe locations must be used. The kernel in equations (1) and (4) thus becomes a matrix, the eigenfunctions become eigenvectors, and the integral becomes a summation.**

The * represents a convolution with respect to time, f is the characteristic event, and g is a random strength function similar to the random arrival time concept. This representation must be used instead of the original shot-noise because the function is continuous rather than a sequence of discrete functions.

It can be shown that

(6)

$$S(x,x';\omega) = F\{f(x,t)\}F^{*}\{f(x',t)\}$$

$S(\omega)$ is the measured spectrum, and F stands for the Fourier transform of the quantity inside the brackets. For $x = x'$ the deterministic function f is found from

(7) $$F\{f\} = [S(\omega)]^{1/2} e^{i\beta}$$

β is an arbitrary phase angle. Different choices for β will lead to different representations of the form given by equation (5). The representation sought is the one that is consistent with the results of the orthogonal decomposition. The quantity defined in equation (6) is equivalent to the kernel in equation (4) and hence can be expanded into the sum of its eigenfunctions. Only the dominant eigenfunction is sought; the remaining functions are neglected and are interpreted essentially as noise in a communication sense [20]. The complex spectrum, with the appropriate choice for β, is given by

(8) $$S(\omega)^{1/2} e^{i\beta} = \lambda_1(\omega)\psi_1(\omega)$$

This choice for β is entirely arbitrary. There is no guarantee that it is correct, but it is believed to be a rational choice.

The spectrum $S(\omega)$ could be called the characteristic spectrum because it determined directly the characteristic event f. Used in conjunction with one another, equations (7) and (8) produce the characteristic event in time, $f(\tau)$, at any particular location x. A more complete description of these developments, as well as its application to an experimental situation, is available [23].

The decomposition has been used previously to a very limited extent. Two Ph.D. theses were conducted under the supervision of Professor J.L. Lumley at the time the technique was being developed. One was an attempt to elucidate the nature of a viscous sublayer [24]. Results showed qualitative agreement with the structure deduced from flow visualization. The other thesis was a study of the wake structure behind a circular cylinder [25]. Results from this experiment were somewhat surprising. The large eddy structure was found to be two counter-rotating vortex pairs whose axes are perpendicular to both the mean flow direction and the cylinder center line. Applications in which turbulence-induced noise is of concern include jet noise and boundary layer noise and vibration.

JET NOISE

The most important practical problem in the area of turbulence-induced noise is jet noise. The problem can be attacked in a number of ways. In the original theoretical development [17] the nonhomogeneous wave equation

(9)

$$\frac{\partial^2 \rho}{\partial t^2} - \frac{1}{a_o^2}\frac{\partial^2 \rho}{\partial x_i^2} = \frac{\partial^2}{\partial x_i \partial x_j} T_{ij}$$

was derived. T_{ij} is the Lighthill stress tensor, which for practical purposes is given by the approximation

(10) $$T_{ij} \sim \rho_o U'_i U'_j$$

The quantity on the right side of equation (10) is considered the source term. The approximate solution is found as [17]

(11)

$$\rho - \rho_o \sim \frac{1}{4\pi a_o^2}\frac{x_i x_j}{x^3} \int \frac{1}{a_o^2}\frac{\partial^2}{\partial t^2}[T_{ij}]dy$$

The brackets indicate that T_{ij} is evaluated at the retarded time, $t - r/a_o$.

One possible mode of attack would be to measure the appropriate turbulence quanti-

ties in order to specify T_{ij} accurately, insert the value into equation (11), and solve the equation numerically for the density perturbation. However, this monumental task cannot be carried out; in addition, the nature of the noise sources would not be elucidated. The problem with direct computations of this type is that the most important terms are not singled out.

A better procedure would be to insert certain candidate structures into T_{ij} to test their effectiveness as noise radiators. The candidate structures could be obtained from the results of the orthogonal decomposition. The simplest case would be a test of the hypothesis that the large structures radiate noise directly. The idea has been proposed before, but the candidate structure -- vortex pairing -- was merely suggested [126]; it was not found from an unbiased experiment. To date there is no experimental evidence that vortex pairing occurs in an experiment involving high Reynolds number and high Mach number.

A candidate for T_{ij} would be much more difficult to formulate if large-structure small-structure interaction is the dominant noise source. The large structure could result from the orthogonal decomposition, but incorporating the random small scales may be difficult. Interactions of this type have been studied theoretically, but both large scales and small scales were hypothesized [27]. If large scales resulting from the decomposition are used, various scenarios could be tested in an attempt to determine how the interaction takes place. This idea has been put forth previously [8].

An alternative to using the result of the decomposition as data for equation (11) would be to compare the result directly to an orthogonal decomposition of the noise field. This comparison shows the most promise for discovering the nature of the noise sources. It has been attempted in a cooperative effort involving the St. Anthony Falls Hydraulic Laboratory and two other institutions. Each institution was to carry out a difference phase of the experiment. Problems arose because three facilities and three different size nozzles (different Mach numbers but the same Reynolds number were used; a more complete description is available [28]. The conclusion reached is that the experiment must be conducted in one facility at a constant Mach number. Turbulence studies conducted at low Mach number -- where hot wires are easy to use — cannot be used to infer the nature of noise sources at higher Mach number.

BOUNDARY LAYER NOISE AND VIBRATION

The physics of boundary layer noise are sufficiently different from jet noise that the preceding ideas are not directly applicable. It is believed that the coherent structure plays a dominant role in jet noise. They play a more passive role in boundary layers. Noise and vibration resulting from a boundary layer occur at low wave numbers. (Low wave numbers are defined as those with wavelengths much longer than the boundary layer thickness.) Turbulence induces low wave number pressure fluctuations along the boundary that are efficient in radiating noise. Such pressure fluctuations are of prime interest in underwater sound and structural vibration. The problem is that the amplitude is so low that measurements accurate enough to be compared with various theories have yet to be conducted. All efforts have thus far failed. An orthogonal decomposition using some new techniques in spectral estimation designed specifically for this situation is outlined below.

The pressure fluctuations at any point along the boundary are considered stationary and homogeneous. Strictly speaking the boundary layer grows in the downstream direction, but growth is slow enough to be approximately homogeneous. The cross stream direction is strictly homogeneous, but at present this direction is neglected. Only streamwise fluctuations are of concern. The pressure signal is written as

$$P = P(x,t) \tag{12}$$

where x is the streamwise coordinate and t is time.

The appropriate decomposition for each variable is the harmonic decomposition by Fourier transform methods. This is easily carried out on a digital computer by a fast Fourier transform (FFT) algorithm. It is

accurate only if sufficient data are available. In the time domain sufficient data are easily obtained by choosing an appropriate sampling rate and sampling period. Generally 256 points or 1024 points are used.

A practical limitation on the number of transducer locations in the spatial domain arises for two reasons: only a finite number of transducers can be fitted into the measurement area, and considerable effort is required to obtain 256 separate correlation measurements. Thus, even though Fourier analysis is correct, the FFT algorithm cannot be used to decompose the spatial structure because of finite data length. Alternative spectral estimators geared to the limited number of transducers must be sought.

The most common spectral estimator for this application is called beamforming [29]. A finite transducer array is used to define the beam power for frequency ω

(13)

$$b_n(\omega) = \frac{V_n^H S(\omega) V_n}{K^2} \qquad n = 1,N$$

$S(\omega)$ is the cross-spectral density matrix, V_n is the steering vector, and N is the number of transducers. The steering vector takes the form

(14) $$V_n^{\,i} = \exp\{j(kd_i = \phi)\}$$

where d_i is the distance between the transducers and ϕ is an arbitrary phase. The most common form used in boundary layer pressure measurements is an alternating phase array [30]. Different transducer separations are used to steer the array to different wave numbers; the full wave number spectrum cannot be found from a single array.

An alternative to beamforming now being developed belongs to a class of spectral estimators known as the maximum likelihood method (MLM) [31]. The technique was originally developed for geophysical problems but has been used for estimating source bearing in radar and sonar applications. It appears to produce better agreement with model spectra [32] than beamforming but has not yet been applied to actual data.**

The wall pressure signal is written as in equation (12); the desired output is harmonic decomposition of each of the independent variables x and t. Thus, the desired output is in the form of a frequency wave number spectrum $\Phi(\omega, k)$ in which the amplitude or energy content is given as a function of frequency ω and wave number k.

The general procedure is to perform a frequency decomposition for every possible pair of transducers. A cross-spectral density matrix of the form

$$S(x,x';\omega) = \begin{bmatrix} \square & \square & \square & \cdots \\ \square & \square & \square & \\ \square & & & \\ \cdot & & & \\ \cdot & & & \\ \cdot & & & \end{bmatrix}$$

can be written for each frequency component ω. This matrix is the same as that given in equation (4). The variables x and x' denote measurement locations. The elements on the main diagonal of this matrix correspond to power spectra; the off-diagonal elements correspond to cross power spectra for various transducer separations. This set of matrices, one for each frequency component, is operated on by the MLM to estimate the wave number frequency spectrum.

The output of the application of the MLM to each matrix is in the form of a wave number spectrum for each frequency. The method applied to Chase's [32] model spectrum is shown in Figure 2. The MLM spectrum reproduces the Chase model much better than the direct Fourier transform estimate (beamforming) over the entire wave number spectrum. In the future the method will be fine tuned to focus on the low wave number region.

**A more complete technical manual on the MLM is being developed by the authors of reference 31.

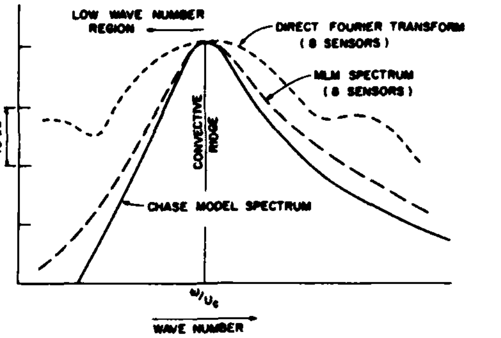

Figure 2. Comparison of the Direct Fourier Transform Spectral Estimation (Beamforming) and the MLM Spectral Estimate Using Chase's Model as the Input

SUMMARY

The techniques described in this paper are aimed at identifying patterns in the turbulence responsible for noise and vibration. Previous efforts in this direction suffered from some bias associated with the procedure. The intent has been to eliminate this bias as much as possible and to let a rigorous analytical black box educe the large structure from the random field. The resulting quantitative measure can be compared to other programs using the same analytical black box to study turbulence changes in response to different parameters.

With the advent of high-speed digital data acquisition and computing circuitry, the problem of implementing the black box has been eliminated. It is hoped that these techniques will be used more often in the future to establish a larger data base from which useful comparisons can be made.

ACKNOWLEDGEMENTS

Thanks are due to M. Kaveh and G. Wakefield of the Electrical Engineering Department at the University of Minnesota for supplying information on the maximum likelihood method. This work was sponsored by the Office of Naval Research.

REFERENCES

1. Schlichting, H., Boundary Layer Theory, 7th Edition, McGraw-Hill (1979).

2. Kline, S.J., Reynolds, W.C., Schraub, F.A., and Runstadler, P.W., "The Structure of Turbulent Boundary Layers," J. Fluid Mech., 30, p 741 (1967).

3. Corino, E.R. and Brodkey, R.S., "A Visual Investigation of the Wall Region in Turbulent Flow," J. Fluid Mech., 37, p 1 (1969).

4. Becker, H.A. and Massaro, T.A., "Vortex Evolution in a Round Jet," J. Fluid Mech., 31, p 435 (1968).

5. Beavers, G.S. and Wilson, T.A., "Vortex Growth in Jets," J. Fluid Mech., 44, p 97 (1970).

6. Winant, C.D. and Browand, F.K., "Vortex Pairing: The Mechanism of Turbulent Mixing Layer Growth at Moderate Reynolds Number," J. Fluid Mech., 63, p 273 (1974).

7. Brown, G.L. and Roshko, A., "On Density Effects and Large Structure in Turbulent Mixing Layers," J. Fluid Mech., 64, p 775 (1974).

8. Arndt, R.E.A. and George, W.K., "Investigation of the Large Scale Coherent Structure in a Jet and Its Relevance to Jet Noise," 2nd Symp. Transportation Noise, Raleigh, NC, p 142 (1974).

9. Moore, C.J., "The Role of Shear Layer Instability Waves in Jet Exhaust Noise," J. Fluid Mech., 80, p 321 (1977).

10. Crighton, D.G., "Acoustics as a Branch of Fluid Mechanics," J. Fluid Mech., 106, p 261 (1981).

11. Long, D.F. and Arndt, R.E.A., "Jet Noise at Low Reynolds Number," AIAA J., 22, p 187 (1984).

12. Lighthill, M.J., "On Sound Generated Aerodynamically: II. Turbulence as a Source of Sound," Proc. Royal Soc. London, Ser. A, 222, p 1 (1954).

13. Kibens, V., "Discrete Noise Spectrum Generated by an Acoustically Excited Jet," AIAA J., 18, p 343 (1980).

14. Long, D.F., Kim, H.J., and Arndt, R.E.A., "Controlled Suppression or Amplification of Turbulent Jet Noise," AIAA J., 23, p 828 (1985).

15. Lush, P.A., "Measurements of Subsonic Jet Noise and Comparison with Theory," J. Fluid Mech., 46, p 477 (1971).

16. Ahuja, K.K. and Bushell, K.W., "An Experimental Study of Subsonic Jet Noise and Comparison with Theory," J. Sound Vib., 30, p 325 (1973).

17. Lighthill, M.J., "On Sound Generated Aerodynamically: I. General Theory," Proc. Royal Soc. London, Ser. A, 211, p 564 (1952).

18. Chandrsuda, C., Mehta, R.D., Weir, A.D., and Bradshaw, P., "Effect of Free-stream Turbulence on Large Structure in Turbulent Mixing Layers," J. Fluid Mech., 85, p 693 (1978).

19. Wygnanski, I., Oster, D., Fiedler, H., and Dziomba, B., "On the Perserverence of Quasi Two-Dimensional Eddy-Structure in a Turbulent Mixing Layer," J. Fluid Mech., 93, p 325 (1979).

20. Lumley, J.L., Stochastic Tools in Turbulence, Academic Press (1970).

21. Loeve, M., Probability Theory II, 4th Edition, Springer-Verlag (1978).

22. Rice, S.O., "Mathematical Analysis of Random Noise," Bell System Tech. J., Vols. 23 and 24; also in Noise and Stochastic Processes, Dover (1954), N. Wax (ed).

23. Long, D.F. and Arndt, R.E.A., "The Orthogonal Decomposition of Pressure Fluctuations Surrounding a Turbulent Jet," 5th Symp. Turbulent Shear Flows (Aug 1985).

24. Bakewell, H., "The Viscous Sublayer and Adjacent Wall Region in Turbulent Pipe Flow," Ph.D. Thesis, Pennsylvania State University (1966).

25. Payne, F.R., "Large Eddy Structure of a Turbulent Wake," Ph.D. Thesis, Pennsylvania State University (1966).

26. Ffowcs-Williams, J.E. and Kempton, A.J., "The Noise from the Large Scale Structure of a Jet," J. Fluid Mech., 84, p 673 (1978).

27. Gatski, T.B. and Liu, J.T.C., "On the Interactions between Large-Scale Structure and Fine-Grained Turbulence in a Free Shear Flow; III: A Numerical Solution," Phil. Trans. Royal Soc., London, 293, p 473 (1980).

28. Long, D.F., "Viscous and Compressibility Effects on the Orderly Structure in Turbulent Jets," Ph.D. Thesis, University of Minnesota. In preparation.

29. Johnson, D.H., "The Application of Spectral Estimation Methods to Bearing Estimation Problem," IEEE Proc., 70 (9), p 1018 (1982).

30. Blake, W.K. and Chase, D.M., "Wave Number-Frequency Spectra of Turbulent Boundary Layer Pressure Measured by Microphone Arrays," J. Acoust. Soc. Amer., 49, p 862 (1971).

31. Wakefield, G.H. and Kaveh, M., "Frequency-Wave Number Spectral Estimation of Non Planar Random Fields," Proc. Intl. Conf. Acoust., Speech, Signal Processing, Paper No. 21.5 (1985).

32. Chase, D.M., "Modeling the Wave Vector Frequency Spectrum of Turbulent Boundary Layer Wall Pressure," J. Sound Vib., 70, p 29 (1980).

BOOK REVIEWS

TWO PHASE FLOW AND WATERHAMMER LOADS IN VESSELS, PIPING AND STRUCTURAL SYSTEMS

F.J. Moody, Ed.
ASME, PVP-Vol. 91, New York, NY
1984, 102 pages, H00305

This book is a collection of nine papers that were presented at the 1984 Pressure Vessels and Piping Conference and Exhibition, June 17-24, 1984, at San Antonio, Texas.

The papers are a cohesive presentation of the latest development in the analytical treatment of shock flow, waterhammer, and jet flow. The papers address the treatment of shock and waterhammer problems arising in the design of nuclear or conventional power plant piping systems. The majority of papers were written by individuals directly connected to power company engineering staffs.

The nine papers are:

"A Method for Waterhammer Analysis of Control Rod Drive Piping," G.C. Mok

"The Effect of Compressible Pipe Lining on Waterhammer Wave Velocity," R.A. Uffer

"The Effect of Encroachments on Structure Impact Loads during a Pool Swell Transient," E.J. McNamara

"A Methodology for Calculating a Check Valve Closure Following a Postulated Line Break," J.C. Rommel, S.A. Traiforos, and J.H. Bell

"A Procedure for Predicting Temperature Loadings for Thermal Stress Calculations in Thick-Walled Pipes," B.T. Amos and F.J. Moody

"Calculation of Waterhammer Load Resulting from Rapid Steam Bubble Condensation," A. Attia and S. Ruhl

"Modeling Two-Phase Jet Flow," E. Elias, J.M. Healzer, A. Singh, and F.J. Moody

"The Prediction of the Strength of Weak to Moderately Strong Shock Waves in Two-Phase Fluids," A.H. Wiedermann

"An Approximate Solution of Steamhammer Using Real Gas Properties," D. Katze and G. Ernest

The book is well edited and has only a few obvious typographical errors. The editor is to be commended for a brief introduction at the beginning of the book; it includes a preparatory recommended reading list for "entry level or established workers" in the field. This is a helpful approach to the reader. The book is recommended for anyone concerned with shock and waterhammer piping problems.

K.E. Hofer
L.J. Broutman & Assoc. Ltd.
Consulting and Testing Services
3424 S. State St.
Chicago, IL 60616

PIPING ENGINEERING TODAY: INNOVATIVE SOLUTIONS THROUGH ANALYSIS, TESTING, AND EXPERIENCE

E.V. Stijgeren, Ed.
ASME, PVP-Vol. 90, New York, NY
1984, 162 pages, H00304

This book is a collection of 16 papers that were presented at the 1984 Pressure Vessels and Piping Conference and Exhibitions on June 17-21, 1984, at San Antonio, Texas. It was sponsored by the pressure vessels and piping division of ASME.

Three of the papers deal with seismic analysis. The paper by Zalak et al has absolutely nothing to do with piping; rather, it treats missile isolation during seisive ground motion. About half the papers present innovative piping components; the other half present computer analytical processes for various piping problems. Three papers treat snubber concepts and analyses. Five papers deal with analysis and testing of piping supports, trays, or hangers. The 16 papers are:

"Generic Design and Qualification of Non-Seismic Category B31.1 Tubing," T.M. Adams and D. Merkovsky

"Generic Design and Qualification of Seismic Category Tube Tray Structures for the Support of B31.1 Instrumentation Tubing," D. Merkovsky and T.M. Adams

"Design Considerations for Supporting Uninsulated Cryogenic Piping," J.J. Pothanikat and A.O. Medellin

"Sodium-Water Reaction Piping Structural Analysis Validation Using Test Results," M.R. Schrag

"Development and Plant Specific Applications of Pressurizer Safety Valve Discharge Loadings," L.C. Smith and K.C. Chang

"Instability Analysis of Piping System," M.Z. Lee and T.S. Jan

"Piping Analysis Computer Program Evaluation," M.Z. Lee

"Design Problems in Modular Construction," S.C. Lou

"Fatigue Failure of Piping Equipment Caused by Flow-Induced Vibrations," A. Shulemovich

"APAD: Preprocessing Program for Pipe Anchor Reinforcement Pad Analysis," T.F. Trimble and T.J. Kim

"Seismic Interference Criteria for Power, Petrochemical and Process Plants," V.M. Zalak and R. Sankar

"Constant Supports -- How Constant?" E.C. Goodling and R.A. DeLoskey

"Snubber Lockup Velocity by Extension of the Response Spectra Method," R.J. Gurdal, W.D. Maxham, and M.K. Punatar

"Response Sensitivity of Piping Systems to Large Lock Up Velocities in Hydraulic Snubbers," M.A. Pickett and S.K. Sinha

"Testing of Welded, Two-Directional Pipe Straps," C.N. Rentschler

"Parametric Studies on the Load-Deflection Characteristics of Hydraulic Snubbers," M. Subudhi, J. Curreri, P. Bezler, and M. Hartzman

Most of the papers are readable. A variety of writing styles and skills are illustrated. The audience addressed by the papers does not appear to have cohesive interests because testing, analysis, mathematics, and design are addressed. The book will be of major interest to piping designers and engineering firm libraries.

K.E. Hofer
L.J. Broutman & Assoc. Ltd.
Consulting and Testing Services
3424 S. State St.
Chicago, IL 60616

THE DYNAMICS OF PRECISE TAPE DRIVES

K. Ragulskis, P. Varanauskas, V. Lelinas, R. Bentkus, and A. Andriuskevicius
Leidykla Mokslas, Vilnius, USSR
1984 (In Russian)

The material in this book is based on work conducted by the authors in the time period between 1970 and 1980 at the scientific research division -- Vibrotechnica -- of Kaunas Polytechnic Institute. Dynamic analysis models of tape drives, effective methods for the determination of natural frequencies, and primary forms of vibration are described. Questions on the dynamics of basic nodes are examined. The dynamic precision of tape drives when subjected to accidental disturbances is estimated. Methods and synthesis algorithms on frequency spectra are presented, as are methods on dynamic diagnosis.

The first chapter is introductory and includes basic concepts and characteristics of tape drives. Subtopics are: rheological model of a tape drive, dynamic model of tape drives, linearized dynamic model of tape drives, free vibrations of conservative systems, normal coordinates, and free vibrations with damping.

The second chapter presents theory and new mechanisms, the separate links of which, while performing their primary work functions, also have the function of vibroprotection for other links and parts of the system. Sources of disturbance for mechanical vibrations of a working flexible link include various moving masses of the system (pass-by, inertial, and guide rollers), as well as external sources of disturbance. The last factor is especially manifest in on-board mechanical systems of ships. The influence of such disturbances can be avoided by adapting flexible loop-like links. Loops formed by a moving tape damp its mechanical vibrations, which are then not transferred to the working parts. This chapter examines practical working models and presents an algorithm for the optimization of mechanisms with free loops. A dynamic model is formulated that considers nodes of rotation created by the moving tape and the damping of angular oscillations.

The third chapter contains an analysis of engineering methods on the synthesis of tape drives based on frequency spectra. The authors use matrix algebra to develop criteria and algorithms for the synthesis of various tape drives: chainlike, branched, bandlike, having group symmetry or quasisymmetry, and also varying in time parameters. Methods and synthesis algorithms presented can be used for the construction of tape drives taking into account any prohibited zone of frequency interval.

The fourth chapter is devoted to synthesis methods on frequency spectra of tape drives for both conservative and dissipative systems. The fifth chapter contains fairly detailed methods for the dynamic diagnosis of tape drives. Signals containing diagnostic information are examined. Some diagnostic parameters are selected; the precision of their determination is estimated. Attention is focused on the subject of selecting diagnostic information.

The sixth chapter deals with the dynamic precision of recorders. Together with useful signals this precision registers additional random noise that represents the sum of the nonrandom function and stationary random process. Included are formulas for different probabilistic characteristics of recording loss, sound reproduction, and recording of sound reproduction. A method is developed for the separation of concealed periodics and statistical analysis of random noise.

The book offers a sound introduction to the dynamics of tape drives. Each of the subject areas considered by the authors is presented in a clear and concise manner. The book raises important questions, defines its own assumptions and attempts to offer solutions. Readers who are interested in tape drive dynamics and who read Russian will find this volume a welcome addition to their library.

A. Longinow
Wiss, Janney, Elstner Assoc., Inc.
330 Pfingsten Rd.
Northbrook, IL 60062

MECHANICS AND DESIGN OF CAM MECHANISMS

F.Y. Chen
Pergamon Press, Inc., Elmsford, NY
1982, 523 pages

The value of a reference book is often difficult to assess from a cursory reading or a brief period of intensive study. Its true value is probably best measured by the position it maintains on the engineer's bookshelf and by how often it is used in day-to-day work. In this respect, Professor Chen's book is a success. To those engineers interested in cam design, this book will be a welcome compilation of material previously unavailable in a single source.

Chapter 1 is an introduction to cam mechanisms. It includes a comparison with linkages, as well as cam classification,

nomenclature, and design considerations. According to the author, the remaining 16 chapters are divided into the following four subject areas:

I. Kinematics. Chapters 2 through 8 cover basic cam motion curves, polynomial curves, combined motion curves, and numerical techniques for creating and modifying cam motion curves. Also under this heading is Chapter 9, which covers graphical and analytical methods for determining cam profile coordinates and cutter coordinates.

II. Static Force Analysis. Under this heading are Chapter 10 on force transmission and Chapter 13 on static force and torque calculations.

III. Dynamics. This heading includes Chapter 14 on modeling, Chapter 15 on formulation and solution of the differential equations of motion, and Chapter 16 on dynamic response of typical cam and follower systems.

IV. Design. This is somewhat of a catch-all heading. It includes Chapter 11, cam radius of curvature; Chapter 12, contact stress and wear; and Chapter 17, computer-aided design and optimization of cam mechanisms.

In addition, there are two appendices. The first is a tabulation of factors that simplify the calculation of displacement, velocity, and acceleration for several common cam curves. The second appendix provides a listing of 11 FORTRAN computer programs developed from material in the text.

Generally, the book is easy to read, the figures are clear, and the methods presented are well-illustrated by way of example problems. Unfortunately, however, there are no end-of-the-chapter homework problems for students. Portions of the text are suitable for a graduate-level course in cam design, but the teacher of such a course should select the material carefully and be prepared to supply his own homework problems.

This review would be incomplete without relating the sad and difficult circumstances under which the book was published. Professor Fan Y. Chen died in December, 1981, after a very brief illness. He was, at that time, in the midst of a final proofreading of the text. His wife, Chi-fang, and their two daughters completed the proofreading and saw the book through to publication. As a result, errors remain in the final printing that perhaps would have been corrected had Professor Chen lived. It is to the credit of the publishers that, when these errors came to their attention after the final printing, they sought the aid of technical advisors in completing an errata that has been printed and bound with the book.

This book is a complete, up-to-date reference that should be valuable to both practicing design engineers and to teachers of kinematics and mechanical design.

C. Reinholtz
Assistant Professor
Department of Mechanical Engineering
Virginia Polytechnic Institute
and State University
Blacksburg, VA 24061

SHORT COURSES

JANUARY

SHAFT CRACK DETECTION
Dates: January 14-16, 1986
Place: Atlanta, Georgia
Dates: January 28-30, 1986
Place: Chicago, Illinois
Dates: February 18-20, 1986
Place: Anaheim, California
Objective: The seminar will cover a number of subjects, including vibration measurement transducer applications, filters for shaft crack detection, data presentation formats, rotor mode shape identification, shaft crack documentation, on-line crack detection method, and transient crack detection method. Case histories will be presented on shaft crack detection on a vertical pump, radial cracking on a turbine generator shaft, spiral cracking on a turbine generator shaft, detection of a shaft crack on a boiler feed pump, and laboratory testing results on shaft crack detection. Workshops on mode shape identification, shaft crack detection, and effects of shaft cracks on balancing will also be featured.

Contact: Bently Rotor Dynamics Research Corp., P.O. Box 157, Minden, NV 89423 -800-227-5514, Ext. 9682.

FEBRUARY

VIBRATION AND SHOCK SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS, AND CALIBRATION
Dates: February 3-7, 1986
Place: Santa Barbara, California
Dates: March 10-14, 1986
Place: Washington, DC
Dates: May 12-16, 1986
Place: Detroit, Michigan
Dates: June 2-6, 1986
Place: Santa Barbara, California
Dates: August 18-22, 1986
Place: Santa Barbara, California
Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis; also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 East Los Olivos Street, Santa Barbara, CA 93105 -(805) 682-7171.

MACHINERY MONITORING
Dates: February 11-13, 1986
Place: Houston, Texas
Dates: February 25-27, 1986
Place: Tampa, Florida
Dates: April 22-24, 1986
Place: Philadelphia, Pennsylvania
Dates: May 20-22, 1986
Place: Chicago, Illinois
Dates: June 10-12, 1986
Place: Anaheim, California
Objective: The seminar focuses on the principles of vibration measurement for rotating machinery monitoring. Subjects covered in the seminar include troubleshooting, calibration and maintenance of monitoring systems, and the applications and installation of displacement, velocity, and acceleration transducers.

Contact: Bently Nevada's Customer Information Center, P.O. Box 157, Minden, NV 89437 - 800-227-5514, Ext. 9682.

MACHINERY VIBRATION ANALYSIS I
Dates: February 11-14, 1986
Place: Orlando, Florida
Dates: August 19-22, 1986
Place: New Orleans, Louisiana
Dates: November 11-14, 1986
Place: Chicago, Illinois

Objective: This course emphasizes the role of vibrations in mechanical equipment instrumentation for vibration measurement, techniques for vibration analysis and control, and vibration correction and criteria. Examples and case histories from actual vibration problems in the petroleum, process, chemical, power, paper, and pharmaceutical industries are used to illustrate techniques. Participants have the opportunity to become familiar with these techniques during the workshops. Lecture topics include: spectrum, time domain, modal, and orbital analysis; determination of natural frequency, resonance, and critical speed; vibration analysis of specific mechanical components, equipment, and equipment trains; identification of machine forces and frequencies; basic rotor dynamics including fluid-film bearing characteristics, instabilities, and response to mass unbalance; vibration correction including balancing; vibration control including isolation and damping of installed equipment; selection and use of instrumentation; equipment evaluation techniques; shop testing; and plant predictive and preventive maintenance. This course will be of interest to plant engineers and technicians who must identify and correct faults in machinery.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

DYNAMIC BALANCING
Dates: February 19-20, 1986
April 23-24, 1986
June 18-19, 1986
Place: Columbus, Ohio
Objective: Balancing experts will contribute a series of lectures on field balancing and balancing machines. Subjects include: field balancing methods; single, two and multi-plane balancing techniques; balancing tolerances and correction methods. The latest in-place balancing techniques will be demonstrated and used in the workshops. Balancing machines equipped with microprocessor instrumentation will also be demonstrated in the workshop sessions, where each student will be involved in hands-on problem-solving using actual armatures, pump impellers, turbine wheels, etc., with emphasis on reducing costs and improving quality in balancing operations.

Contact: R.E. Ellis, IRD Mechanalysis Inc., 6150 Huntley Road, Columbus, OH 43229 - (614) 885-5376.

MARCH

MEASUREMENT SYSTEMS ENGINEERING
Dates: March 10-14, 1986
Place: Phoenix, Arizona
MEASUREMENT SYSTEMS DYNAMICS
Dates: March 17-21, 1986
Place: Phoenix, Arizona
Objective: Electrical measurements of mechanical and thermal quantities are presented through the new and unique "Unified Approach to the Engineering of Measurement Systems." Test requestors, designers, theoretical analysts, managers and experimental groups are the audience for which these programs have been designed. Cost-effective, valid data in the field and in the laboratory, are emphasized. Not only how to do that job, but how to tell when it's been done right.

Contact: Peter K. Stein, Director, 5602 East Monte Rosa, Phoenix, AZ 85018 - (602) 945-4603; (602) 947-6333.

MACHINERY DIAGNOSTICS
Dates: March 11-14, 1986
Place: San Francisco, California
Dates: March 17-21, 1986
Place: Carson City, Nevada
Dates: April 8-11, 1986
Place: Atlanta, Georgia
Dates: May 5-9, 1986
Place: Carson City, Nevada
Dates: June 16-20, 1986
Place: Carson City, Nevada
Dates: June 24-27, 1986
Place: Denver, Colorado
Objective: This seminar instructs rotating machinery users on transducer fundamentals, the use of basic diagnostic techniques, and interpreting industry-accepted vibration data formats to diagnose common rotating machinery malfunctions.

The seminar includes class demonstrations, case histories, and a hands-on workshop that allows participants to diagnose malfunctions on demonstrator rotor systems.

Contact: Bently Nevada's Customer Information Center, P.O. Box 157, Minden, NV 89437 - 800-227-5514, Ext. 9682.

APRIL

ROTATING MACHINERY VIBRATIONS

Dates: April 14-16, 1986
Place: Orlando, Florida
Objective: This course provides participants with an understanding of the principles and practices of rotating machinery vibrations and the application of these principles to practical problems. Some of the topics to be discussed are: theory of applied vibration engineering applied to rotating machinery; vibrational stresses and component fatigue; engineering instrumentation measurements; test data acquisition and diagnosis; fundamentals of rotor dynamics theory; bearing static and dynamic properties; system analysis; blading analysis; life estimation; practical rotor blading-bearing dynamics examples and case histories; rotor balancing theory; balancing of rotors in bearings; rotor signature analysis and diagnosis; and rotor-bearing failure prevention.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, Il 60514 - (312) 654-2254.

APPLIED VIBRATION ENGINEERING

Dates: April 14-16, 1986
Place: Orlando, Florida
Objective: This intensive course is designed for specialists, engineers and scientists involved with design against vibration or solving of existing vibration problems. This course provides participants with an understanding of the principles of vibration and the application of these principles to practical problems of vibration reduction or isolation. Some of the topics to be discussed are: fundamentals of vibration engineering; component vibration stresses and fatigue; instrumentation and measurement engineering; test data acquisition and diagnosis; applied spectrum analysis techniques; spectral analysis techniques for preventive maintenance; signal analysis for machinery diagnostics; random vibrations and processes; spectral density functions; modal analysis using graphic CRT display; damping and stiffness techniques for vibration control; sensor techniques for machinery diagnostics; transient response concepts and test procedures; field application of modal analysis for large systems; several sessions on case histories in vibration engineering; applied vibration engineering state-of-the-art.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

MACHINERY VIBRATION ANALYSIS II

Dates: April 28 - May 2, 1986
Place: Syria, Virginia
Objective: The objective of this course is to expose participants to advanced techniques of vibration analysis using single- and dual-channel FFT analyzers. These techniques include analysis of spectrum, time, frequency, and orbital domain; modal analysis; coherence, frequency response functions, and synchronous time averaging; and amplitude, phase, and frequency modulation. Data processing procedures are reviewed. All techniques are illustrated with examples and case histories of industrial machinery. Instrumentation necessary to implement the techniques is available for use by participants during informal workshops; taped data from actual industrial machinery are used during these workshops.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

JULY

ROTOR DYNAMICS

Dates: July 14-18, 1986
Place: Rindge, New Hampshire

Objective: The role of rotor/bearing technology in the design, development and diagnostics of industrial machinery will be elaborated. The fundamentals of rotor dynamics; fluid-film bearings; and measurement, analytical, and computational techniques will be presented. The computation and measurement of critical speeds vibration response, and stability of rotor/bearing systems will be discussed in detail. Finite elements and transfer matrix modeling will be related to computation on mainframe computers, minicomputers, and microprocessors. Modeling and computation of transient rotor behavior and nonlinear fluid-film bearing behavior will be described. Sessions will be devoted to flexible rotor balancing including turbogenerator rotors, bow behavior, squeeze-film dampers for turbomachinery, advanced concepts in troubleshooting and instrumentation, and case histories involving the power and petrochemical industries.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

AUGUST

VIBRATIONS OF RECIPROCATING MACHINERY

Dates: August 19-22, 1986
Place: New Orleans, Louisiana
Objective: This course on vibrations of reciprocating machinery includes piping and foundations. Equipment that will be addressed includes reciprocating compressors and pumps as well as engines of all types. Engineering problems will be discussed from the point of view of computation and measurement. Basic pulsation theory --including pulsations in reciprocating compressors and piping systems -- will be described. Acoustic resonance phenomena and digital acoustic simulation in piping will be reviewed. Calculations of piping vibration and stress will be illustrated with examples and case histories. Torsional vibrations of systems containing engines and pumps, compressors, and generators, including gearboxes and fluid drives, will be covered. Factors that should be considered during the design and analysis of foundations for engines and compressors will be discussed. Practical aspects of the vibrations of reciprocating machinery will be emphasized. Case histories and examples will be presented to illustrate techniques.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

SEPTEMBER

MODAL TESTING OF MACHINES AND STRUCTURES

Dates: September 8-11, 1986
Place: Chicago, Illinois
Objective: Vibration testing and analysis associated with machines and structures will be discussed in detail. Practical examples will be given to illustrate important concepts. Theory and test philosophy of modal techniques, methods for mobility measurements, methods for analyzing mobility data, mathematical modeling from mobility data, and applications of modal test results will be presented.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

ABSTRACTS FROM THE CURRENT LITERATURE

ABSTRACT CONTENTS

AVAILABILITY OF PUBLICATIONS ABSTRACTED

None of the publications are available at SVIC or at the Vibration Institute, except those generated by either organization.

Periodical articles, society papers, and papers presented at conferences may be obtained at the Engineering Societies Library, 345 East 47th Street, New York, NY 10017; or Library of Congress, Washington, D.C., when not available in local or company libraries.

Government reports may be purchased from National Technical Information Service, Springfield, VA 22161. They are identified at the end of bibliographic citation by an NTIS order number with prefixes such as AD, N, NTIS, PB, DE, NUREG, DOE, and ERATL.

Ph.D. dissertations are identified by a DA order number and are available from University Microfilms International, Dissertation Copies, P.O. Box 1764, Ann Arbor, MI 48108.

U.S. patents and patent applications may be ordered by patent or patent application number from Commissioner of Patents, Washington, D.C. 20231.

Chinese publications, identified by a CSTA order number, are available in Chinese or English translation from International Information Service, Ltd., P.O. Box 24683, ABD Post Office, Hong Kong.

Institution of Mechanical Engineers publications are available in U.S.: SAE Customer Service, Dept. 676, 400 Commonwealth Drive, Warrendale, PA 15096, by quoting the SAE-MEP number.

When ordering, the pertinent order number should always be included, not the DIGEST abstract number.

A List of Periodicals Scanned is published in issues, 1, 6, and 12.

MECHANICAL SYSTEMS

ROTATING MACHINES

85-2407

Vibration of a Motor on Viscoelastic Foundation Due to Whirling of the Shaft with Consideration of Electromagnetic Forces

K. Nagaya, S. Ikeda
Gunma Univ., Kiryu, Gunma 376, Japan
J. Vib., Acoust., Stress Rel. Des., Trans. ASME, 107 (3), pp 310-318 (July 1985, 12 figs, 5 refs

KEY WORDS: Shafts, Viscoelastic foundations, Whirling, Electromagnetic excitation

This paper discusses bending vibration characteristics of a rotating shaft of a motor with consideration of the electromagnetic sucking force which acts on a rotor caused by the narrow electromagnetic field between a stator and the rotor. The dynamic response of the motor under the action of the whirling load of the shaft has been analyzed systematically by considering both the translational and rotary motions of the motor. In the analysis the transfer matrix method is used to obtain the response of the shaft. Numerical calculations have been carried out for the natural frequencies, the response of the motor shaft, and the response and the transmissibility of the motor.

85-2408

On the Free and Forced Torsional Vibration of Multi-Disk Shaft Systems

L.A. Bergman, J.W. Nicholson
University of Illinois, Urbana-Champaign, IL
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, FL, spons. AIAA/ASME/-ASCE/AHS, Part 2, pp 515-521, 3 figs, 2 tables, 11 refs

KEY WORDS: Shafts, Torsional vibration, Damped structures

A method to analyze the free and forced torsional vibration of viscously damped circular cylindrical shafting carrying a multiplicity of viscously damped linear oscillators and/or rigidly attached disks. The resulting solution is exact when the system is proportionally damped, and approximate otherwise due to truncation.

85-2409

The Effect of Aerodynamic and Structural Detuning on Turbomachine Supersonic Unstalled Torsional Flutter

D. Hoyniak, S. Fleeter
NASA Lewis Res. Ctr., Cleveland, OH
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, FL, spons. AIAA/ASME/-ASCE/AHS, Part 2, pp 500-514, 20 figs, 1 table, 11 refs

KEY WORDS: Rotors, Flutter, Torsional vibration, Fluid-induced excitation, Turbomachinery

A mathematical model is developed to predict the unstalled torsion flutter of an aerodynamically and structurally detuned rotor operating in a supersonic inlet flow field with a subsonic leading edge locus. Stet detuning is considered. The aerodynamic detuning is accomplished by alternating the circumferential spacing of adjacent rotor blades. To demonstrate the effects of aerodynamic and structural detuning on supersonic unstalled torsional flutter, a twelve bladed rotor based on Verdon's Cascade B flow geometry is considered.

85-2410

Instability of Rotors Mounted in Fluid Film Bearings with a Negative Cross-Coupled Stiffness Coefficient

J.S. Rao
Indian Inst. of Technology, New Delhi-110016, India
Mech. Mach. Theory, 20 (3), pp 181-187 (1985), 5 figs, 2 tables, 14 refs

KEY WORDS: Rotors, Fluid-film bearings, Stiffness coefficients, Unbalanced mass response

This paper is concerned with the instability of a rotor mounted in fluid film bearings that can occur when one of the cross-coupled stiffness coefficients of the bearing is negative. It has been shown that his instability occurs in a narrow zone of speed at 2 Xrev frequency. In practice, this can be an important consideration for rotors with asymmetry such as generator rotors.

85-2411

Measurements of Wake-Generated Unsteadiness in the Rotor Passages of Axial Flow Turbines

H.P. Hodson

Cambridge Univ., Cambridge, UK

J. Engrg. Gas Turbines Power, Trans. ASME, 107 (2), pp 467-476 (Apr 1985), 17 figs, 3 tables, 26 refs

KEY WORDS: Rotors, Stalling, Rotor-stator interaction, Fluid-induced excitation

This paper describes an investigation into the free-stream unsteadiness which is found in the rotor passages of axial flow turbines and which is caused by the interaction of the stator wakes with the rotor blades. The major part of this investigation was conducted at the midspan of the rotor of a large-scale, single-stage air turbine.

85-2412

A Theoretical Model for Rotating Stall in the Vaneless Diffuser of a Centrifugal Compressor

P. Frigne, R. Van den Braembussche

CERAC, CH-1024, Ecublens, Switzerland

J. Engrg. Gas Turbines Power, Trans. ASME, 107 (2), pp 507-513 (Apr 1985), 10 figs, 20 refs

KEY WORDS: Centrifugal compressors, Stalling

A theoretical model for rotating stall in the vaneless diffuser of a centrifugal compressor is presented. It consists of a time-evolutive calculation of the strong interaction between the inviscid flow core and the unsteady boundary layers along the walls. It is shown that, depending on the diffuser geometry and the diffuser inlet flow angle, a transient perturbation of the outlet static pressure will generate a rotating flow pattern.

85-2413

Rotating Stall Induced in Vaneless Diffusers of Very Low Specific Speed Centrifugal Blowers

Y. Kinoshita, Y. Senoo

Kyushu Univ., Fukuoka 816, Japan

J. Engrg. Gas Turbines Power, Trans. ASME, 107 (2), pp 514-521 (Apr 1985), 10 figs, 13 refs

KEY WORDS: Blowers, Stalling

The limit of rotating stall was experimentally determined for three very small specific centrifugal blowers. The impellers were specially designed for stall-free at very small flow rates, so that the cause of rotating stall could be attributed to the vaneless diffusers. Experimental results demonstrated that the blowers did not stall until the flow coefficient was reduced to very small values, which had never been reported in the literature.

85-2414

Radial and Tangential Flow Fans — An Alternative to Axial Flow Fans For Low Noise Automotive Cooling Systems

R.V. Hofe, G.E. Thien

AVL List Ges.m.b.H., Graz, Austria

Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Society of Automotive Engrs., Warrendale, PA, pp 221-230, 11 figs, 14 refs

KEY WORDS: Fans, Cooling systems, Motor vehicles, Noise reduction

Investigations have been carried out into the suitability of radial flow fans as a replacement for axial flow fans. Project objectives were to reduce cooling system noise without increasing bulk volume or impairing efficiency. These considerations apply

particularly to vehicles with engines of high output.

85-2415

Aerodynamically Excited Vibrations of a Part-Span Shrouded Fan

A.V. Srinivasan, D.G. Cutts

United Technologies Res. Ctr., East Hartford, CT 06108

J. Engrg. Gas Turbines Power, Trans. ASME, 107 (2), pp 399-407 (Apr 1985), 17 figs, 7 refs

KEY WORDS: Fans, Shrouds, Aerodynamic loads, Tuning, Vibration measurement

The structural response of a part-span shrouded fan due to an aerodynamic excitation was measured using strain gages. The excitation was provided by means of a 4-lobed distortion screen mounted upstream of the rotor. Vibration measurements made with tuned and mistuned conditions at integral order speeds have been analyzed to determine the aeromechanical response characteristics of the assembly. The results from the experimental investigation are presented and discussed.

85-2416

Investigation of Flow Phenomena in a Transonic Fan Rotor Using Laser Anemometry

A.J. Strazisar

NASA Lewis Res. Ctr., Cleveland, OH 44135

J. Engrg. Gas Turbines Power, Trans. ASME, 107 (2), pp 427-435 (Apr 1985), 10 figs, 2 tables, 15 refs

KEY WORDS: Fans, Shock response, Lasers, Fluid-induced excitation

Several flow phenomena, including flow field periodicity, rotor shock oscillation, and rotor shock system geometry have been investigated in a transonic low aspect ratio fan rotor using laser anemometry. Flow periodicity is found to increase with increasing rotor pressure rise and to correlate with blade geometry variations.

RECIPROCATING MACHINES

85-2417

Combustion Noise from High Speed Direct Injection Diesel Engines

M.F. Russell, R. Haworth

Lucas Industries Noise Centre, Lucas CAV Limited, Acton, London

Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Society Automotive Engrs., Warrendale, PA, pp 95-116, 27 figs, 1 table, 13 refs

KEY WORDS: Diesel engines, Engine noise, Combustion noise, Noise measurement

A simple technique has been developed for measuring the noise radiated by diesel engine surfaces in response to combustion excitation. Results using this technique correlate well with the established computer-based analysis technique.

85-2418

Characteristics of Exciting Forces and Structural Response of Turbocharged Diesel Engines

T. Priede, J.M. Baker, E.C. Grover, R. Ghazy

Southampton Univ., Southampton, UK

Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Society of Automotive Engrs., Warrendale, PA, pp 85-93, 18 figs, 3 refs

KEY WORDS: Diesel engines, Bearings, Time domain method, Frequency domain method

The paper quantifies the forces applied to the main bearings of three six-cylinder turbocharged diesel engines and reviews their exciting properties in both time and frequency domains. The engine structure response at the bearing supports and the outer engine surfaces are correlated. It is shown that the engine structure response is a transient phenomenon and is a maximum in the vicinity of the applied force.

85-2419
Recent Advances in Diesel Engine Research
P.E. Waters
P.E. Waters & Associates
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Society of Automotive Engrs., Warrendale, PA, pp 345-358, 11 figs, 61 refs

KEY WORDS: Diesel engines, Noise reduction

This paper reviews some recent research in diesel engineering that points the way to possible solutions to the problems facing engine designers in the next 10 to 20 years. These problems are: the need for improved thermal efficiency an multifuel capability to deal with future supplies of fuel for transport and the need to make the engine more socially acceptable by reducing its noise and air pollutant emissions.

85-2420
Engine Structure Analysis for Low Noise — The Options
M.D. Croker
Ricardo Consulting Engineers
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Society of Automotive Engrs., Warrendale, PA, pp 75-83, 20 figs, 22 refs

KEY WORDS: Reciprocating engines, Engine noise, Noise reduction

Within the limitations of the combustion process the engine structure remains the key to reducing radiated noise levels. This paper reviews the various techniques available for engine structure analysis in the context of the ever increasing computational power available to the design engineer.

POWER TRANSMISSION SYSTEMS

85-2421
Interactive Computer Simulation of Drivetrain Dynamics
M.C. Tsangarides, W.E. Tobler, C.R. Heermann
Ford Motor Co.
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Society of Automotive Engrs., Warrendale, PA, pp 143-158, 17 figs, 25 refs

KEY WORDS: Driveline vibrations, Computerized simulation, Torsional response

Computer simulations of vehicle dynamics can be a useful investigative tool in driveability. As the present work demonstrates, oscillations of the drivetrain under steady-state and transient conditions are amenable to mathematical analysis, especially in the torsional mode. Simulations of such a system with a lock-up torque converter are shown with emphasis on tip-in response, transmissibility of engine firing pulsations and self-excited oscillations.. In particular, the method of interactive simulation is shown to be an effective design-aid tool in the investigation of drivetrain vibrations.

85-2422
Research on Idling Rattle of Manual Transmission
S. Ohnuma, S. Yahata, M. Inagawa, T. Fujimoto
Mitsubishi Motors Corp., Tokyo, Japan
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Society of Automotive Engrs., Warrendale, PA, pp 159-167, 21 figs, 13 refs

KEY WORDS: Power transmission systems, Gear boxes, Torsional vibrations, Diesel engines

Generation mechanism and characteristics of idling rattle are systematized analytically by experiments on vehicle and digital simulation of nonlinear torsional vibration system for an inline four-cylinder four-cycle diesel engine.

METAL WORKING AND FORMING

85-2423
Dynamic Characteristics of Lathe Using Concrete Bed

I.S. Chung, M. Tsutsumi, Y. Ito
Jeonbug National Univ., Jeonju, Korea
Bull. JSME, 28 (239), pp 987-993 (May 1985), 17 figs, 4 refs

KEY WORDS: Lathes, Damping materials, Concrete

This paper describes the dynamic characteristics of a lathe using a concrete bed. The concrete has attracted special interest as a structural material for its low cost of production and good damping properties. The effects of the concrete bed on the vibration and noise levels of the structure and the dynamic stiffness of a work-spindle system are mainly investigated.

MATERIALS HANDLING EQUIPMENT

85-2424
Forces in the Hoisting Wire of a Crane Barge in Waves
Zu Deyao
Harbin Shipbuilding Engrg. Inst., China
Ocean Engrg., 12 (1), pp 1-16 (1985), 4 figs, 10 tables, 6 refs

KEY WORDS: Cranes (hoists), Barges

In this report a description is given of a method by which the influence can be determined of the dynamic motions of a derrick barge and of the object to be hoisted on the forces in the hoisting wire. The results of these calculations are used for an optimization study in which several parameters of the hoisting system have been varied.

STRUCTURAL SYSTEMS

BRIDGES

85-2425
Three-Dimensional Response of a Concrete Bridge System to Traveling Seismic Waves
B. Dendrou, S. Werner, T. Toridis
George Washington Univ., Washington, DC
Computers Struc., 20 (1-3), pp 593-603 (1985), 8 figs, 3 tables, 21 refs

KEY WORDS: Bridges, Reinforced concrete, Seismic response, Substructuring methods, Computer programs

To enhance the evaluation of the bridge response to seismic excitations there is a need to incorporate more parameters in an analytical model. This paper describes a methodology for analysis of traveling seismic wave effects on the dynamic response of an elastic concrete bridge. A substructuring approach is used to efficiently model the bridge/soil dynamic interaction.

85-2426
Dynamic Theory of Trains Passing Through a Railway Bridge - A Study of Effects of the Masses and Inertia Forces of Moving Load
Ye Kaiyuan, Ma Guolin
SSA, 27 (8), pp 831-846 (1984), CSTA No. 625.1-84.28

KEY WORDS: Railroad bridges, Moving loads, Bridge-vehicle interaction

This paper uses analytic method to investigate the dynamic calculation of the whole process of trains passing through a railway bridge and considers effects of the mass and the damping effect of the bridge as well as the masses of moving loads.

CONSTRUCTION EQUIPMENT

85-2427
In-Place-Dynamic Sound Power Test Method
W.H. Flint
Caterpillar Tractor Co.
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Society of Automotive Engrs., Warrendale, PA, pp 277-282, 7 figs, 1 table, 3 refs

KEY WORDS: Construction equipment, Sound measurement, Measurement techniques

ISO and SAE static sound power test methods are currently used for construction machinery. The European Economic Community sound committee has been developing a drive-by or simulated work cycle test method using a hemispherical array microphones. The EEC method is inconsistent due to the changing test surface (moist sand) and the variables of outdoor testing: temperature, wind, and precipitation. The in-place-dynamic test method described provides a disciplined way to evaluate machines with moving track or wheels and operating hydraulic systems.

OFF-SHORE STRUCTURES

85-2428
Approximative Formulae for Calculating the Motions of Semi-Submersibles
J.A. van Santen
Marine Structure Consultants, 3370 AC Hardinxveld-Giessendam, The Netherlands
Ocean Engrg., 12 (3), pp 235-252 (1985), 10 figs, 6 refs

KEY WORDS: Submersed structures, Heaving, Off-shore structures

This paper discusses approximative methods to be used in the determination of the heave motions of semi-submersibles. These methods can be useful in the design stage as they circumvent the use of large computer programs.

85-2429
Resonant Heave Motion of Semisubmersible Vessels
C.L. Kirk
Cranfield Inst. of Technology, Cranfield, Bedford MK43 0AL, UK
Ocean Engrg., 12 (2), pp 177-184 (1985), 2 figs, 12 refs

KEY WORDS: Submersed structures, Heaving, Offshore structures

This paper is concerned with nonlinear resonant heave motion of a semisubmersible vessel at the survival draft. Due to the small potential damping of the hulls at deep draft the resonant motion is governed almost entirely by nonlinear drag forces on the hull and bracing members.

VEHICLE SYSTEMS

GROUND VEHICLES

85-2430
Vehicle Sound Measurement — 20 Years of Testing
T. M. Howell, R. F. Schumacher
Ford Motor Company
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Society of Automotive Engrs., Warrendale, PA, pp 61-73, 5 figs, 2 tables, 38 refs

KEY WORDS: Ground vehicles, Noise measurement, Measurement techniques

Various SAE vehicle noise test subcommittees have been involved in numerous programs to improve and expand the applicability of procedures for increasing exterior noise levels and their relationship to the ever changing product lines. Parallel to this work, governmental and trade associations have also sought changes to better reflect the true measure of noise impact on the community. The evolution of testing has resulted in a continuing improvement in the quality of the test data.

85-2431
Development of an Interior Sound Level Measurement Procedure for Light Vehicles — SAE J1477

K.S. Bagga, E.P. Repick
American Motors Corporation, Detroit, MI
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Society of Automotive Engrs., Warrendale, PA, pp 293-302, 2 figs, 2 tables, 4 refs

KEY WORDS: Ground vehicles, Motor vehicles, Interior noise, Noise measurement, Measurement techniques

With increase emphasis on comparing interior noise performance levels of passenger cars, multi-purpose vehicles, and light trucks, a need existed for the establishment of a recommended practice for making interior sound level measurements. Many variables, such as environmental conditions, instrumentation and vehicle test parameters exist that make accurate comparisons of vehicle interior sound levels difficult at best. The new proposed SAE Recommended Practice J1477-XXX8X, Measurement of Interior Sound Levels of Light Vehicles, establishes a procedure for making vehicle interior sound level measurements. Environmental conditions, instrumentation set up and analysis, and vehicle test conditions are described in detail.

85-2432
Component Mode Synthesis of a Vehicle Structural-Acoustic System Model
S.H. Sung, D.J. Nefske
General Motors Research Laboratories, Warren, MI
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/ASME/ASCE/AHS, Part 2, pp 628-635, 8 figs, 25 refs

KEY WORDS: Component mode synthesis, Automobiles, Interior noise, Noise prediction, Design techniques

Application of the component mode synthesis technique to develop an analytical structural-acoustic system model of an automotive vehicle is described. The system model combines an acoustic finite element model of the automobile passenger compartment cavity with finite element and modal models of the vehicle structural system. The model can be solved for frequency, random, and transient response to predict the low-frequency interior noise which occurs during actual operating conditions of the vehicle. The theoretical formulation of the model is described, as well as an experimental verification for random input.

85-2433
An Application of Structural-Acoustic Analysis to Car Body Structure
H. Yashiro, K.-i. Suzuki, Y. Kajio, I. Hagiwara
Nissan Motor Co., Ltd.
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Society of Automotive Engrs., Warrendale, PA, pp 337-344, 17 figs, 8 refs

KEY WORDS: Automobiles, Interior noise, Building block approach

In order to calculate efficiently the characteristics of car body vibration and the acoustic characteristics of the passenger-compartment, a structural-acoustic analysis system, CAD-B, was developed. This system divides the body into three components -- front body, main cabin and rear body. The characteristics of front and rear body vibration are expressed in modal parameters.

85-2434
A Study of Vehicle Interior Noise Using Statistical Energy Analysis
R.G. DeJong
Cambridge Collaborative, Inc., Cambridge, MA
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Society of Automotive Engrs., Warrendale, PA, pp 1-6, 12 figs, 7 refs

KEY WORDS: Motor vehicles, Interior noise, Statistical energy methods

The noise vibration of an automotive vehicle is studied using statistical energy analysis (SEA). Three sources of interior noise

-- the engine, tires, and air flow -- have been measured and used as inputs to the SEA model. The flow of acoustic energy through various structural components is calculated in order to determine the dominant paths of noise transmission to the passenger compartment. The predicted interior noise levels are compared to those measured under different operating conditions.

85-2435

A Study of Noise in Vehicle Passenger Compartment during Acceleration

K. Tsuge, K. Kanamaru, T. Kido, N. Masuda
Toyota Motor Corp.
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Society of Automotive Engrs., Warrendale, PA, pp 27-34, 16 figs, 4 tables, 1 ref

KEY WORDS: Automobiles, Interior noise, Engine noise

A discomforting noise (rumbling) sometimes heard in a vehicle passenger compartment during acceleration is investigated. A detailed study of the rumbling noise spectrum clarified the generating mechanism of the rumbling noise and the relation between the spectral structure and the tone. In order to analyze the rumbling noise it was simulated with electrically synthesized noise. This method showed that at times when the noise is heard there are more than three discrete harmonics which are half an order harmonics of the engine revolution. The sensation of discomfort depends on the phase, frequency and magnitude of each frequency component.

85-2436

A Review of Parameters Affecting the Noise and Vibration in Diesel Powered Passenger Cars

E. Winklhofer, G.E. Thien
AVL List Ges.m.b.H., Graz, Austria
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Society of Automotive Engrs., Warrendale, PA, pp 35-43, 17 figs, 1 table, 9 refs

KEY WORDS: Automobiles, Diesel engines, Interior noise

The noise and vibration properties of diesel engines call for increased efforts in manufacturing passenger cars to achieve a level of comfort comparable to gasoline cars. Starting with measurements of vehicle interior noise reasonable limits of diesel engine noise and vibration levels and sound and vibration transmission properties are defined.

85-2437

Engine Encapsulation on 6-10 Ton-Trucks

M. Stiglmaier, H.-J. Drewitz
M.A.N.
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Society of Automotive Engrs., Warrendale, PA, pp 117-122, 11 figs

KEY WORDS: Trucks, Traffic noise, Engine noise, Noise reduction

A noise-reducing capsule for distribution trucks with 6 to 10 tons g.v.w. (class 3 to class 6) has been developed. This capsule reduces the drive-past noise by approximately 6 dB(A) and at the same time reduces the noise level in the cab by approximately 3 dB(A). All component temperatures remain inside the permissible ranges; the functionability of vehicles with capsules is retained in full. The dead weight of the trucks is increased by approximately 40 kg.

85-2438

Quiet Heavy Vehicles for 1990 -- The QHV 90 Programme

C.G.B. Mitchell
Transport and Road Research Laboratory, Crowthorne, Berkshire, England
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Society of Automotive Engrs., War-

rendale, PA, pp 195-202, 2 figs, 4 tables, 20 refs

KEY WORDS: Trucks, Noise reduction

The British Government has set up a program of research and support for development to assist the manufacturers of heavy goods vehicles and their engines to develop products that will comply with new noise limits and be available for production by 1990. The program called QHV 90 is described.

85-2439
Vehicle Response to Throttle Tip-In/Tip-Out
R.A. Krenz
Ford Motor Company
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Society of Automotive Engrs., Warrendale, PA, pp 45-51, 6 figs, 1 table, 3 refs

KEY WORDS: Automobiles, Transient response

Throttle tip-in/tip-out maneuvers generate a driveline torque transient which may produce an objectionable disturbance to vehicle occupants. Recent developments in vehicle design have contributed to increased severity in this response, which is known as clunk and shuffle. Experimental procedures which have been developed to quantify response levels and diagnose cases of concern are described. Specific design and calibration modifications, which control clunk and shuffle, are also described.

85-2440
Fatigue Analysis of Ground Vehicle Components
R.W. Landgraf
Ford Motor Company, Dearborn, MI
Vehicle Structures, Intl. Conf., Institution of Mech.E., London, Conf. Pub. 1984-7, SAE-MEP 200, pp 101-108, 8 figs, 2 tables, 17 refs

KEY WORDS: Ground vehicles, Fatigue life, Computer programs

Recent advances in material and structural fatigue methodology are reviewed in the context of their applicability to ground vehicle design. The construction and utilization of a package of interactive computer program modules that enable the formulation and solution of a wide variety of ground vehicle fatigue problems is also described. Examples are presented to demonstrate the use of such a tool at various stages of the product development and validation cycle.

85-2441
Fatigue Life Distribution of Vehicle Frame Structures
M. Matolcsy, C. Molnar
Research Institute of Automobile Industry, Autokut, Budapest, Hugary
Vehicle Structures, Intl. Conf., Institution of Mech.E., London, Conf. Pub. 1984-7, SAE-MEP 200, pp 121-130, 9 figs, 8 refs

KEY WORDS: Ground vehicles, Structural members, Fatigue life, Crack propagation

A theoretical description is given of the life distributions in the case of stochastically loaded vehicle structural elements. This method is based on the extreme stress distribution from one side, and on the service strength distribution from the other side. The service strength is derived from the crack propagation functions as well as from the residual strength of cracked structural elements.

85-2442
Fatigue Design of PM Automotive Components
C.M. Sonsino, W.J. Huppmann
Fraunhofer-Institut fur Betriebsfestigkeit (LBF), Darmstadt, W. Germany
Intl. J. Vehicle Des., 6 (3), pp 297-310 (May 1985) 11 figs, 3 tables, 15 refs

KEY WORDS: Automobiles, Fatigue life, Design techniques

Among several competing mass-production methods powder metallurgy plays an impor-

tant role not only as a material and energy saving alternative, but also as a technique delivering materials with good fatigue properties. The power metallurgical component design procedure is illustrated by two examples: a conventionally sintered turbocharger bushing and a powder forged parking gear. Both parts were previously designed using conventional wrought steels.

85-2443
Laboratory Methods for Evaluating Car Body Structure-Dynamics and Durability Performance
B. Singh
Austin Rover Group Limited, Oxford
Vehicle Structures, Intl. Conf., Institution of Mech.E., London, Conf. Pub. 1984-7, SAE-MEP 200, pp 115-120, 5 figs, 5 refs

KEY WORDS: Automobiles, Testing techniques, Fatigue tests

Laboratory based test techniques and equipment used for evaluating car body structure dynamics and fatigue performance are discussed.

85-2444
Modelling Problems in the Dynamic Design of Autobuses
P. Michelberger, A. Keresztes, S. Horvath
The Technical Univ. of Budapest, Hungary
Vehicle Structures, Intl. Conf., Inst. of Mech.E., London, Conf. Pub. 1984-7, SAE-MEP 200, pp 195-200, 3 figs, 7 refs

KEY WORDS: Buses, Fatigue life

The complete stress statistics of bus structures require a linearity analysis of the vehicle to establish exact and approximate ranges of computation results. In coefficient matrices of motion equations the rather significant effects of the payload have to be considered separately.

85-2445
Dynamics and Design
F.D. Hales
Univ. of Technology, Loughborough, UK
Intl. J. Vehicle Des., 6 (3), pp 257-262 (May 1985)

KEY WORDS: Motor vehicles, Design techniques

The relationship between the study of dynamics and design of vehicles is discussed.. A conflict exists at present as the numerical data for dynamic analysis is often not available until late in the design process, at a stage when design flexibility may have become limited. It is proposed here that in the future there will be more linkage between dynamic studies and computer aided design, with a trend towards engineers who have the ability to teach computers not only to draw but also what to draw.

85-2446
Computer Aided Concept Design of a Sports Car Chassis System
D.J. Fothergill, R. Southall, E. Osmond
SDRC Engrg. Services Ltd., Hitchin, Hertfordshire, UK
Vehicle Structures, Intl. Conf., Inst. of Mech.E., London, Conf. Pub. 1984-7, SAE-MEP 200, pp 91-99, 8 figs, 3 tables

KEY WORDS: Automobiles, Design techniques, Computer aided techniques

A process is described that was used to design a chassis system for a sports car with a non structural plastic body skin. The main concern was to achieve a design with adequate stiffness to promote good handling and ensure that whole vehicle vibration would be satisfactorily controlled. Simple, cost effective computer modeling was used to predict the stiffness of an initial scheme. The chassis model was developed into a dynamic simulation of the whole vehicle.

85-2447
A New Technique for Field Damage Simulation of Elastically Coupled Structures
J.N. Fletcher, R.E. Jones

Surface Vehicle Noise and Vib. Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Society of Automotive Engineers, Warrendale, PA, pp 329-335, 10 figs, 12 refs

KEY WORDS: Off-highway vehicles, Structural members, Damage prediction, Modal analysis

A technique for field durability testing of elastically mounted components of off-road vehicles has been developed which simplifies the replication of field damage on these structures. The procedure combines the techniques of cumulative damage and modal analysis to replace the usual multi-shaker excitation technique with a much simpler physical system. This method allows field damage studies to be performed with less laboratory equipment and setup. Initial work has shown that the method is very effective in predicting field failures in an accelerated laboratory test.

85-2448

An Optimization Method for Crashworthiness Design

Ji Oh Song

General Motors Res. Labs., Warren, MI 48090

Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held Apr 15-17, 1985, Orlando, FL, Spons. AIAA/ASME/-ASCE/AHS, Part 1, pp 365-372, 10 figs, 2 tables, 6 refs

KEY WORDS: Optimization, Design techniques, Crashworthiness, Collision research (automotive)

A new optimization capability, which determines the dimensions of the structural components, is developed to minimize the structural mass while meeting given safety criteria. The study uses both the nonlinear spring-mass model and beam models in a hybrid manner such that the optimizer interfaces with the spring-mass model, which in turn interfaces with the beam models to obtain force deformation curves required as input. A scale factor representing the stiffness change of a beam due to its design change is introduced to generate the approximate force-deformation curve of the beam during optimization.

85-2449

Finite Element Modelling of Vehicle Bodies Using Substructuring Methods

M.D. Austin, G.G. Moore

Austin Rover Group, Oxford, UK

Vehicle Structures, Intl. Conf., Instn. of Mech.E, London, Conf. Pub. 1984-7, SAE-MEP 200, pp 83-89, 6 figs

KEY WORDS: Ground vehicles, Finite element technique, Substructuring methods

Earlier finite element modeling methods treated the entire body structure, or one half if symmetry permitted, as a single model. The need to evaluate structures in greater detail led to complex models which produced large volumes of unmanageable data and were inefficient to run. A substructured approach has been developed which reduced these problems. The method uses commercially available software for model preparation and analysis, together with in-house software for interfacing between a draughting geometry database and the modeling database, and for pre- and post-processing of the analysis files.

85-2450

An On-Board Crash Test Data Acquisition System

S.P.F. Petty

Transport and Road Res. Lab., Crowthorne, Berkshire, UK

Vehicle Structures, Intl. Conf., Instn. Mech.E., London, Conf. Pub. 1984-7, SAE-MEP 200, pp 11-12

KEY WORDS: Collision research (automotive), Testing techniques, Data recorders

Problems in the data acquisition system used when vehicle structures are crash tested has resulted in the formation of a task group to produce a specification for an alternative system. The evolution of the specification from its original simple concept to its final form is described.

85-2451
Trends in the Design of Car Front and Side Structures to Meet Future Safety Needs
I.D. Neilson
Transport and Road Res. Lab., Crowthorne, Berkshire, UK
Vehicle Structures, Intl. Conf., Instn. of Mech.E., London, Conf. Pub. 1984-7, SAE-MEP 200, pp 1-6, 1 table, 11 refs

KEY WORDS: Collision research (automotive), Design techniques

A review of the current situation regarding car occupants and pedestrians injured in road accidents involving cars is presented. The compulsory use of seat belts has transformed the situation and the paper deals with the structural aspects of what should be done next in car design. The discussion suggests how all safety needs may be achieved in one design of front structure.

85-2452
Evaluation of the Structural Integrity of Intermediate Buses
F.F. Monasa
Michigan Technological Univ., Houghton, MI
Vehicle Structures, Intl. Conf., Instn. of Mech.E., London, Conf. Pub. 1984-7, SAE-MEP 200, pp 207-215, 8 figs, 16 refs

KEY WORDS: Buses, Collision research (automotive)

The results obtained from evaluation of the structural integrity, under accident situations, of intermediate buses are presented. A method based on the finite element modeling technique and a nonlinear structural analysis procedure is used. The results for rollover, side impact, and front impact loading conditions are presented graphically as load-deflection diagrams along with the three-dimensional analytical model of the passenger compartment framework showing the sequence of plastic hinge formation, for each loading condition, up to collapse.

85-2453
The Use of the National Highway Traffic Safety Administration's Vehicle Crash Test Data Base in a Study of Vehicle Structural Responses
J.R. Hackney
National Highway Traffic Safety Admn., Washington, DC
Vehicle Structures, Intl. Conf., Instn. of Mech.E., London, Conf. Pub. 1984-7, SAE-MEP 200, pp 13-20, 6 figs, 3 tables, 4 refs

KEY WORDS: Collision research (automotive), Experimental data

The National Highway Traffic Safety Administration's vehicle crash test data base which contains information on almost 700 vehicles is providing the data for extensive studies of vehicle structural responses. An example of a study shows the significance of vehicle crash pulses to potential occupant injuries.

85-2454
Future Trends in the Simulation of Crashworthiness
G.H. Tidbury
Cranfield Inst. of Technology, Cranfield, Bedford, UK
Vehicle Structures, Intl. Conf., Instn. of Mech.E., London, Conf. Pub. 1984-7, SAE-MEP 200, pp 21-28, 6 figs, 29 refs

KEY WORDS: Collision research (automotive), Crashworthiness

The development of crash simulation is traced for the two main aspects of accident simulation and vehicle design. It is shown that useful information can be obtained on both these aspects by the use of classical mechanics with simplified structural crush parameters. Because of the complication of the complete simulation of the crush behavior of sheet metal structures the method of idealizing the front of a car as a series of masses connected by nonlinear springs generally attributed to Kamal is described.

85-2455
Numerical Calculation of the Bending

Collapse of Two Structural Car Safety Components
T. Scharnhorst
Volkswagenwerk AG, Forschung, Wolfsburg, W. Germany
Vehicle Structures, Intl. Conf., Instn. of Mech.E., London, Conf. Pub. 1984-7, SAE-MEP 200, pp 29-38, 11 figs, 21 refs

KEY WORDS: Collision research (automotive), Finite element techniques, Damage prediction

Nonlinear finite element techniques are applied to a longitudinal car beam and the bending collapse of a steering tube column. Results are compared to measurements and suggest that these numerical techniques can be applied in a predictive manner and that they are useful in reducing the amount of component testing.

85-2456
Modelling the Collapse of Cars in Asymmetrical Barrier Impact Tests
M. Brennan, M. Macaulay, A. Wynn-Ruffhead
University College, London WC1, UK
Vehicle Structures, Intl. Conf., Instn. of Mech.E., London, Conf. Pub. 1984-7, SAE-MEP 200, pp 39-45, 10 figs, 1 table, 4 refs

KEY WORDS: Collision research (automotive), Impact tests, Guardrails

The development and use of a two-dimensional lumped-mass computer model to simulate cars deforming in frontal barrier impact tests is described. The masses are chosen to be representative of two types of car for which impact data were available, and the load-deflection characteristics of the structural members are fitted to the behavior of these two cars in the symmetrical frontal impact test and two different asymmetrical tests. Use is made of operator controlled and automatic optimzing routines.

85-2457
Twisting Collapse of Open Sections
A.M.S. Al-Sheikh, M.A. Nanayakkara, P.W. Sharman
University of Technology, Loughborough, UK
Vehicle Structures, Intl. Conf., Instn. of Mech.E., London, Conf. Pub. 1984-7, SAE-MEP 200, pp 47-51, 9 figs, 7 refs

KEY WORDS: Collision research (automotive), Design techniques, Automobiles, Energy absorption

In the design of cars, and other safety sensitive systems, it is essential that the energy of impact is absorbed in progressively deforming parts of the structure, particularly in regions which are relatively unimportant in terms of the primary purpose. The large deformations experienced by open sections during collapse may be conveniently described by discrete mathematical methods, utilizing finite elements and powerful incremental programs accounting for plasticity as well as the large displacements.

85-2458
Influence of Inertia in Structural Crashworthiness
S.R. Reid, C.D. Austin
Univ. of Aberdeen
Vehicle Structures, Intl. Conf., Instn. of Mech.E., London, Conf. Pub. 1984-7, SAE-MEP 200, pp 63-70, 8 figs, 14 refs

KEY WORDS: Crashworthiness, Structural members, Ground vehicles, Tubes, Energy absorption

The effects of inertia on the modes of collapse of two classes of structure are described and discussed. Systems of structural elements which have a monotonically increasing load-deflection curve deform under the influence of structural waves when subjected to impact loading. The behavior of tubular columns is dominated by the effects of instability which are also strongly influenced by the inertia of the structure.

AIRCRAFT

85-2459
Unsteady Flows Around Three-Dimensional Wings
M. Gad-el-Hak
Flow Research Co., Kent, WA
Rept. No. FRC-RR-305, AFOSR-TR-84-1243, 90 pp (Oct 1, 1984), AD-A149 993/-8/GAR

KEY WORDS: Aircraft wings, Fluid-induced excitation

Time-dependent flows around rectangular, swept of delta wings undergoing harmonic pitching motions were investigated using flow visualization techniques. The wings were towed in an 18-m water channel at chord Reynolds numbers up to 350,000. Fluorescent dye layers were excited with a sheet of laser light and used to mark the flow in the separation region around the lifting surface, the wake region and the potential flow away from the wing. The flow field around each wing depends to a large degree on wing planform, leading edge contour, and the reduced frequency of oscillation. The results can be mostly explained in terms of the mutual induction between the leading edge separation vortex and the trailing edge shedding vortex.

85-2460
A New Approach to Durability Prediction for Fuel Tank Skins
M.A. Ferman, W.H. Unger, C.R. Saff, M.D. Richardson
McDonnell Douglas Corp., St. Louis, MO
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 102-109, 14 figs, 6 refs

KEY WORDS: Fuel tanks, Aircraft components, Fatigue life

A potential source of fuel tank leakage, premature fatigue cracks initiated from a newly recognized dynamic loading, is investigated. This new loading source results from fluid structure interaction dynamics between tank skins and fuel mass. Significant strain intensifications are produced, and since they occur at higher frequencies, they cause a reduced fatigue life. It is believed that this approach may help to explain why many instances of premature tank skin fatigue and leakage were not previously predicted by maneuver spectrum fatigue methods. This should provide an improved design approach to minimize fuel leakage from fatigue cracks.

85-2461
An Improved Source Model for Aircraft Interior Noise Studies
J.R. Mahan, C.R. Fuller
Virginia Polytechnic Inst. and State Univ., Blacksburg, VA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 602-608, 8 figs, 1 table, 6 refs

KEY WORDS: Aircraft noise, Interior noise

The present paper exploits an existing analytical model for noise transmission into aircraft cabins to investigate the behavior of an improved propeller source model for use in aircraft interior noise studies. The new source model, a virtually rotating dipole, is shown to adequately match measured fuselage sound pressure distributions, including the correct phase relationships, for published data. As an example of its application, the virtually rotating dipole is used to study the sensitivity of synchropohasing effectiveness to the fuselage sound pressure trace velocity distribution. Results of calculations are presented.

85-2462
Dynamic Loads Analyses of Flexible Airplanes — New and Existing Techniques
A.S. Pototzky, B. Perry, III
Kentron International, Inc., Hampton, VA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-

ASME/ASCE/AHS, Part 2, pp 651-663, 14 figs, 1 table, 19 refs

KEY WORDS: Aircraft, Aerodynamic loads, Mode displacement method, Mode acceleration method, Summation of forces method

Existing techniques for calculating dynamic loads for flexible airplanes are reviewed and a new technique is presented. The new technique involves the summation-of-forces method of writing dynamic loads equations. The new technique uses s-plane approximation methods to transform the dynamic loads equations from a second-order frequency-domain formulation with frequency-dependent coefficients into a linear-time-invariant state-space formulation. Several numerical examples demonstrate the usefulness of the new technique and the high quality of the results.

85-2463

Influence of Warpage on Composite Aeroelastic Theories

G.A. Oyibo, J.H. Berman

Fairchild Republic Co., Farmingdale, NY

Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 330-336, 4 figs, 14 refs

KEY WORDS: Aircraft wings, Warping, Aeroelasticity

The new methodology used as the basic tool in this paper is basically the aeroelastic equivalent of the aerodynamic similarity rule. The influence of warping (spanwise axial constraints on wing twist) on composite wing aeroelastic oscillations is investigated using this approach. Results show that a high-aspect-ratio composite wing could behave aeroelastically like a low aspect ratio wing and vice-versa. Similarity parameters derived in this analysis expose conditions for which this might happen.

85-2464

A New Approach to Apply the Potential Gradient Method for Supersonic Unsteady Airloads

K. Appa

Northrop Corp., Hawthorne, CA

Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 50-55, 4 tables, 10 refs

KEY WORDS: Aircraft wings, Aerodynamic loads, Gradient methods

A new approach in applying the potential gradient method to compute the generalized aerodynamic forces on wing-like lifting surfaces is discussed. An aerodynamic influence coefficient formulation relating the downwash and the panel pressure distributions has been derived. The formulation is such that there is no need to consider the wake or the diaphragm elements in the analysis. Since there is no series expansion of the frequency term in this method, computations at low supersonic Mach numbers and high reduced frequencies can be performed with no convergency difficulties.

85-2465

Wing Rock Flow Phenomena

L.E. Ericsson

Lockheed Missiles and Space Co., Inc., Sunnyvale, CA

Proc. of Workshop on Unsteady Separated Flow held at U.S. Air Force Academy, Aug 10-11, 1983, AD-A148 249, pp 10-20, AD-P004 154/1/GAR

KEY WORDS: Aircraft wings, Fluid-induced excitation

Flow mechanisms that can generate wing-rock type oscillations are described. It is shown that the slender wing rock phenomenon, the limit cycle oscillation in roll observed for very slender delta wings, is caused by asymmetric leading edge vortices and that vortex breakdown can never be the cause of it as it has a damping effect.

85-2466

Effect of Active Control System Nonlinearities on the L-1011-3(ACS) Design Gust Loads

J.D. Gould
Lockheed California Co., Burbank, CA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 468-476, 22 figs, 2 tables, 4 refs

KEY WORDS: Aircraft Wings, Wind induced excitation, Active control, Design techniques

An active control system has been developed for a derivative of the L-1011 which allows an increase in wing span with little increase in design wing loads. An allowance for load increases produced by active control system nonlinear effects has been included in the design loads, and the adequacy of this allowance has been substantiated by a nonlinear simulation of the aircraft and active control system encountering these severe turbulence levels.

85-2467
The Computation of Second-Order Accurate Unsteady Aerodynamic Generalized Forces
B. van Niekerk
Stanford Univ., Stanford, CA 94305
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 56-63, 5 figs, 1 table, 18 refs

KEY WORDS: Airfoils, Aircraft wings, Weighted residual technique, Flutter

A classical variational principle is used to derive special properties of a weighted residual method. It is shown that some weighted integral of the sought solution can be obtained to second-order accuracy in the solution to the original and adjoint problems. For aerodynamic problems, it is assumed that the reverse flow problem is adjoint to the original problem. Examples on airfoils and panel methods demonstrate the fast convergence of generalized aerodynamic forces on airfoils and wings.

85-2468
Transonic Test of a Forward Swept Wing Configuration Exhibiting Body Freedom Flutter
R. Chipman, F. Rauch, M. Rimer, B. Muniz
Grumman Aerospace Corp., Bethpage, NY 11714
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 298-312, 16 figs, 2 tables, 11 refs

KEY WORDS: Aircraft wings, Flutter, Wind tunnel testing

Body freedom flutter is a dynamic instability involving aircraft pitch and wing bending motions which, though rarely experienced on conventional vehicles, is characteristic of forward swept wing (FSW) aircraft. To investigate this aeroelastic phenomenon, tests were conducted on a 1/2- scale, flying, cable-mounted model of a realistic FSW configuration with and without relaxed static stability (RSS).

85-2469
Flutter and Divergence Boundary Prediction from Nonstationary Random Responses at Increasing Flow Speeds
Y. Matsuzaki, Y. Ando
Nagoya Univ., Nagoya, Japan
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 313-319, 7 figs, 20 refs

KEY WORDS: Aircraft wings, Flutter

A locally stationary process method for predicting the flutter and divergence boundaries is presented. The method was applied to response signals of wing models due to flow turbulence measured in subcritical flutter and divergence tests, in which the dynamic pressure was increased at a constant speed with the Mach number being fixed.

85-2470
Measured Unsteady Transonic Aerodynamic Characteristics of an Elastic Supercritical Wing with an Oscillating Control Surface

D.A. Seidel, M.C. Sandford, C.V. Eckstrom
NASA Langley Res. Ctr., Hampton, VA 23665
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 64-71, 13 figs, 10 refs

KEY WORDS: Aircraft wings, Airfoils, Flutter, Wind tunnel tests, Experimental data

Transonic steady and unsteady aerodynamic data were measured on a large elastic wing in a transonic dynamics tunnel. The wing had a supercritical airfoil shape and a leading-edge sweepback of 28.8°. The wing was heavily instrumented to measure both static and dynamic pressures and deflections. A hydraulically driven outboard control surface was oscillated to generate unsteady airloads on the wing. Representative results from the wind tunnel tests are presented and discussed.

85-2471

Coupling Linearized Far-Field Boundary Conditions with Non-Linear Near-Field Solutions in Transonic Flow

W.S. Rowe, F.E. Ehlers
Boeing Commercial Airplane Co., Seattle, WA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 72-82, 24 figs, 6 refs

KEY WORDS: Aircraft, Flutter, Fluid induced excitation

A research investigation has been conducted to evaluate the feasibility of coupling linearized far field solutions with near-field finite differencing equations to reduce the size of grid networks required in transonic flow calculations. A criterion based on the gradient of the flow field Mach number was developed for use in establishing the minimum size grid network necessary for accurate finite thickness unsteady loading predictions.

85-2472

Unsteady Transonic Flow Calculations for Two-Dimensional Canard-Wing Configurations with Aeroelastic Applications

J.T. Batina
NASA Langley Res. Ctr., Hampton, VA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 1-9, 13 figs, 1 table, 13 refs

KEY WORDS: Aircraft wings, Aerodynamic loads, Fluid-induced excitation, Flutter

Unsteady transonic flow calculations for aerodynamically interferring airfoil configurations are performed as a first step toward solving the three-dimensional canard-wing interaction problem. These calculations are performed by extending the XTRAN2L two-dimensional unsteady transonic small-disturbance code to include an additional airfoil. Unsteady transonic forces duke to plunge and pitch motions of a two-dimensional canard and wing are presented.

85-2473

Computer-Aided Frequency Domain Synthesis of a Robust Active Flutter Suppression Control Law

D.K. Schmidt, T.K. Chen
Purdue Univ., West Lafayette, IN
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 459-467, 7 figs, 3 tables, 18 refs

KEY WORDS: Active flutter control, Frequency domain method, Computer-aided techniques, Graphic methods

Computer-aided graphical conventional synthesis techniques are employed to obtain a robust active-flutter-suppression control law. The relatively high dynamic order of such problems are dealt with effectively with a computer-aided approach, while interactive computer graphics allows conventional graphical techniques to be utilized. Key design information is displayed for variations in flight conditions such that a simple control law is obtained that is

robust over the variation in the flight condition

85-2474

Flutter Control with Unsteady Aerodynamic Models

Shyang Chang

Ph.D. Thesis, Univ. of California, Los Angeles, 106 pp (1984), DA8428493

KEY WORDS: Aircraft, Flutter, Vibration control

This dissertation deals with a generic problem for aircraft: control laws for flutter suppression. Until recently, the system frequency response was approximated by rational functions so that the finite-dimensional L-Q-R theory could be applied. However, discrepancy between theory and practice, especially in the transient response, has led to renewed interest in the problem. A time-domain model for unsteady aerodynamic loads was developed and then coupled with a lumped model for the structural dynamics.

MISSILES AND SPACECRAFT

85-2475

Transient Load Analysis Method for Large Linear Structures with Local Nonlinearities and Its Application to Space Shuttle Payload Load Analysis

M. Kitagawa, K. Kubomura

Rockwell International, Downey, CA 90241

Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 404-416, 11 figs, 16 refs

KEY WORDS: Space shuttle, Transient excitation

The development of a method for a transient load analysis of a large-scale structure with local nonlinearities is described. The results from applying the method to the Space Shuttle payload dynamic loads analysis are presented. The method was formulated by using the finite difference time integration equation developed from the Duhamel integration and interpolating the nonlinear forces during each time interface. Results of an investigation leading to finding the appropriate nonlinear force time interpolation functions are also presented.

85-2476

A Simpler Approach to Update Spacecraft Launch Loads

B.N. Agrawal, P. Grosserode, J.O. Dow

Intl. Telecommunications Satellite Organization, Washington, DC

Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Par 2, pp 417-425, 11 figs, 1 tables, 6 refs

KEY WORDS: Spacecraft, Transient analysis, Launching

A simpler approach is presented to update launch loads for a spacecraft whose structural dynamic characteristics have been modified during its design phase. The spacecraft dynamic characteristics influence the interface acceleration by introducing anti-resonances (notches) at the spacecraft cantilever frequencies. The proposed approach consists of shifting the anti-resonance frequencies in the interface acceleration in accordance with the changes in the natural frequencies of the spacecraft. It provides a significant improvement in the accuracy of the calculated spacecraft launch loads in comparison with the base drive technique.

85-2477

Stability of Flexible Structures with Random Parameters

F. Kozin

Polytechnic Inst. of New York, Brooklyn, NY

Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-

ASME/ASCE/AHS, Part 2, pp 166-172, 3 figs, 11 refs

KEY WORDS: Spacecraft, Stability, Stochastic processes

A brief description of the problem of stability of stochastic systems, results available for the study of stability of continuous parameter structures, and results needed for design applicability are presented.

85-2478
Use of Helium Gas to Reduce Acoustic Transmission
J.G. Blevins, L.L. Hansen
Martin Marietta Denver Aerospace, New Orleans, LA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 96-101, 10 figs, 1 table

KEY WORDS: Spacecraft components, Sound transmission, Launching response, Acoustically induced excitation

Payload enclosures subjected to high energy acoustical environments may have high transmissibility due to coupling between structural and acoustical modes. Reducing transmissibility by mass attenuation, increased absorption or damping causes undesirable weight increases. It is shown that decoupling of the dynamic modes can be achieved without increasing weight by introducing a different gas (helium (He)) inside the enclosure from the ambient gas (air) outside the enclosure. For a certain frequency range, analytical studies of the external tank aft cargo carrier show nearly zero sound reduction through the structure.

85-2479
Low-Authority Control Synthesis for Large Spacecraft Structures, Using Disturbance Propagation Concepts
A.H. von Flotow
German Space Operations Ctr., DFVLR Oberpfaffenhofen, Wessling, Fed. Republic Germany
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 152-160, 12 figs, 23 refs

KEY WORDS: Spacecraft, Active vibration control

This paper introduces the point of view that elastic deformation in large spacecraft structures may be aptly viewed in terms of propagating disturbances. The control concepts which result from such a viewpoint are presented.

85-2480
Integrated Structural/Control Synthesis via Set-Theoretic Methods
A.L. Hale
General Dynamics Convair Div., San Diego, CA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 636-641, 3 tables, 16 refs

KEY WORDS: Spacecraft, Vibration control

An ellipsoidal set-theoretic approach to the integrated structural/control synthesis for vibration regulation of flexible structures such as large space structures is considered. The synthesis attempts to maximize the allowable magnitude of an unknown but bounded disturbance to the structure while explicitly satisfying specific input and output constraints. Both structural parameters and control gains are variable during a search for the maximum allowable disturbance. A simple numerical example is presented to illustrate this synthesis approach.

85-2481
Control of Dynamic Response of a Continuum Model of a Large Space Structure
P.E. O'Donoghue, S.N. Atluri
Georgia Inst. of Technology, Atlanta, GA
Structures, Structural Dynamics and Materi-

als Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 31-42, 14 figs, 3 tables, 23 refs

KEY WORDS: Spacecraft, Vibration control, Equivalent continuum method

The problem of active control of the transient dynamic response of large space structures, modeled as equivalent continua, is investigated. The effects of initial stresses, in the form of in-plane stress resultants in an equivalent plate model, on the controllability of transverse dynamic response, are studied. A singular-solution approach is used to derive a fully coupled set of nodal equations of motion which also include non-proportional passive damping.

85-2482
Direct Computation of Optimal Control of Forced Linear System
S. Utku, Chin-Po Kuo, M. Salama
Duke Univ., Durham, NC 27706
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 454-458, 6 refs

KEY WORDS: Spacecraft, Optimum control theory

The optimal control of a forced linear system may be reduced to that of tracking the system without forces. The solution of the tracking problem is available via the co-state variables method. This procedure is computationally expensive for large order systems. It requires solution of matrix Riccati equation and two final value problems. An alternate approach is outlined for the direct computation of the optimal control. A matrix Volterra integral must be solved. For this purpose two computational schemes are described, and an illustrative example is given.

85-2483
Optimal Structural Modifications to Enhance the Optimal Active Vibration Control of Large Flexible Structures
N.S. Khot, F.E. Eastep, V.B. Venkayya
Air Force Wright Aeronautical Labs., Wright Patterson Air Force Base, OH 45433
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 134-142, 4 figs, 11 tables, 13 refs

KEY WORDS: Spacecraft, Active vibration control, Structural modification techniques, Optimization

This study provides a method of vibration control of large space structures by simultaneously integrating the structure and control design to reduce the structural response from a disturbance encountered. The formulation of the design scheme is obtained by the structural modification of some nominal finite element model, which is controlled in an optimal fashion by a linear regulator, to increase the active modal damping factor beyond that of the nominal structure. The structural modifications are achieved by using a nonlinear mathematical optimization technique.

85-2484
Use of Piezo-Ceramics as Distributed Actuators in Large Space Structures
E.F. Crawley, J. de Luis
Massachusetts Inst. of Technology, Cambridge, MA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 126-133, 8 figs, 1 table, 8 refs

KEY WORDS: Spacecraft, Actuators, Piezoelectricity, Active vibration control

Distributed segmented piezoelectric actuators bonded to an elastic sub-structure in flexure are modelled. A static shear-lag mechanical model for the interface between the piezo-electric and the sub-structure is developed. An example of the integration of the static piezo structure interaction into a simple dynamic model for the beam is given. This model leads to the ability to predict, a priori, the response of the structural member to an excitation voltage applied to the piezo-electric.

85-2485
Inertial Actuator Design for Maximum Passive and Active Energy Dissipation in Flexible Space Structures
D.W. Miller, E.F. Crawley, B.A. Ward
Massachusetts Inst. of Technology, Cambridge, MA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 536-544, 10 figs, 3 tables, 8 refs

KEY WORDS: Spacecraft, Active vibration control, Vibration absorbers (equipment)

The selection of the passive parameters for passive and active inertial vibration absorbers intended for use in large flexible space structures is investigated. Optimal passive vibration absorbers are designed for one and two DOF structural representations using three parameter optimization techniques: minimum maximum steady-state response; pole placement; and quadratic cost minimization. The three techniques yield nearly identical results.

85-2486
Sensitivity of Optimized Control Systems to Minor Structural Modifications
R.T. Haftka, Z. N. Martinovic, W.L. Hallauer, Jr., G. Schamel
Virginia Polytechnic Inst. and State Univ., Blacksburg, VA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 642-650, 6 figs, 7 tables, 8 refs

KEY WORDS: Structural modification techniques, Vibration control

A procedure for checking whether small changes in a structure have the potential for significant enhancements of its optimized vibration control system is described. The procedure has been demonstrated for a flexible laboratory structure controlled by several rate-feedback colocated force-actuator velocity-sensor pairs. Significant improvements in the performance of the control system were obtained with small structural modifications.

85-2487
A Design Technique for Determining Actuator Gains in Spacecraft Vibration Control
G.C. Horner, J.E. Walz
NASA Langley Res. Ctr., Hampton, VA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 143-151, 7 figs, 2 tables, 9 refs

KEY WORDS: Spacecraft, Actuators, Active vibration control, Damping coefficients

A design procedure is described which determines the gains of a diagonal damping matrix to control the vibrations of a flexible structure with application to orbiting spacecraft. The procedure is based on minimizing the energy dissipated by control actuators using nonlinear mathematical programming. A grillage example is used to demonstrate the design process for determining gains for two representative cases. Resulting designs are verified by a finite element analysis of the structure augmented by the control actuators.

85-2488
Damping Synthesis for Flexible Space Structures Using Combined Experimental and Analytical Models
M.L. Soni, B.N. Agrawal
Univ. of Dayton Res. Inst., Dayton, OH
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 552-558, 2 figs, 3 tables, 5 refs

KEY WORDS: Spacecraft, Damping synthesis, Modal synthesis

A procedure is presented for modal and damping synthesis of flexible space structures from subsystem tests and/or analyses. The results of the developed modal and damping synthesis procedure are verified by using a representative flexible space structure including structural joints.

85-2489
A Comparison of the Craig-Bampton and

Residual Flexibility Methods for Component Substructure Representation
D.C. Kammer, M. Baker
Structural Dynamics Res. Corp., San Diego, CA 92121
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 699-706, 5 figs, 1 table, 6 refs

KEY WORDS: Spacecraft, Component mode synthesis

A theoretical and numerical comparison is made between the fixed interface Craig-Bampton method and the free interface methods of MacNeal and Rubin for component substructure representation. The static and dynamic equivalence of the methods is investigated for a restrained substructure. Vector space theory is used to derive a relation which must be satisfied for dynamic equivalence of the Craig-Bampton and Rubin substructure representations.

85-2490
A Cost-Effective Component Modes Analysis for Shuttle Payloads Using a Combination of Frequency Domain and Time Domain Approaches
M. Trubert, L. Peretti
California Inst. of Technology, Pasadena, CA 91109
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 391-403, 9 figs, 1 table, 17 refs

KEY WORDS: Space shuttles, Component mode analysis, Modal analysis, Frequency domain method, Time domain method

Rather than using a frequency domain to solve the entire problem, a combination of the time domain and the frequency domain is sought using the frequency domain only for those areas where the time domain is clearly inefficient or uncertain. In the structural analysis of spacecraft launched on a launch vehicle, an intermediate step to arrive at the structural loads in the spacecraft is the determination of the time histories at the launch vehicle/spacecraft interface (statically determinate or not). The time domain approach is traditionally used to obtain this interface acceleration by merging the launch vehicle and the spacecraft at the modal level. The frequency allows the determination of this new interface acceleration without the need for a new merged system eigenvalue solution and subsequent system modal responses.

85-2491
Effect of Degradation of Material Properties on the Dynamic Response of Large Space Structures
S. Kalyanasundaram, J.D. Lutz, W.E. Haisler, D.H. Allen
Texas A & M Univ., College Station, TX 77843
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 545-551, 10 figs, 17 refs

KEY WORDS: Spacecraft, Composite materials, Natural frequencies, Mode shapes

The effect of degradation of material properties on structural frequencies and mode shapes of large space structures (LSS) is investigated. The difficulty and cost of maintenance of LSS make it a necessity to design these structures to operate with a certain amount of load-induced damage. This damage is commonly observed in fibrous composite media.

85-2492
Dynamic Analysis of a Deployable Space Structure
G.E. Weeks
The Univ. of Alabama, Tuscaloosa, AL
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 43-49, 12 figs, 14 refs

KEY WORDS: Spacecraft, Expandable structures, Natural frequencies, Mode shapes

A mathematical model and a corresponding simulation code have been developed for investigating the free vibration and forced response behavior of a deployable space structure. It is demonstrated that accurate results for frequency and mode shape characteristics can be obtained with only a small number of generalized coordinates and thus, appears to be a more computationally efficient algorithm than the finite element method.

85-2493

General Motion of Gyroelastic Vehicles in Terms of Constrained Modes

G.M.T. D'Eleuterio, P.C. Hughes
Univ. of Toronto, Downsview, Ontario, Canada

Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 384-390, 4 figs, 9 refs

KEY WORDS: Spacecraft, Gyroelastic properties, Modal analysis

The dynamical equations for the general motion of gyroelastic vehicles -- vehicles modeled by a continuum of mass, stiffness and gyricity (stored angular momentum) -- are developed. The motion is expanded in terms of the vehicle's corresponding constrained modes. The associated eigenvalue problem reveals a significant departure from the modal behavior of nongyric elastic vehicles.

85-2494

Collaborative Techniques in Modal Analysis

M.L. Amirouche, R.L. Huston
Univ. of Illinois, Chicago, IL

Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 161-165, 3 figs, 3 tables, 13 refs

KEY WORDS: Spacecraft, Modal analysis, Finite segment method

A new hybrid procedure for determining vibration characteristics of large structures is presented. The procedure combines modal analysis techniques with recently developed techniques of finite-segment modelling. The procedure uses experimental results from modal analysis and scaling procedures to set the parameters for the finite segment model of the structure. Kane's equations are then used to obtain the governing equations of motion.

85-2495

Optimization Using Lattice Plate Finite Elements for Feedback Control of Space Structures

S.E. Lamberson, T.Y. Yang
Purdue Univ., West Lafayette, IN

Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 743-750, 13 figs, 10 refs

KEY WORDS: Spacecraft, Feedback control, Finite element technique, Optimization

Lattice plate finite elements based on a continuum model of a large plate-like lattice space structure examine the effect of variation of several fundamental structural parameters on the natural frequencies and mode shapes of the structure. Reduced order controller design models are developed using modal cost analysis to rank the modes for each set of structural parameter values.

85-2496

Extension of Ground-Based Testing for Large Space Structures

B.K. Wada, C.P. Kuo, R.J. Glaser
California Inst. of Technology, Pasadena, CA

Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 477-483, 2 figs, 4 tables, 6 refs

KEY WORDS: Spacecraft, Testing techniques, Boundary condition effects

The results of the multiple boundary conditions test approach, which provides a complete ground test of a large structure that will provide, in turn, the data necessary to construct a test-verified final mathematical model, is presented. Theoretical studies indicate that this approach can provide a better final model than a ground test of the full-scale very flexible structure in a 1-g field.

85-2497

Structural Dynamic Model Reduction Using Worst Case Impulse Response Criteria for Large Flexible Space Structures.

A.S.S.R. Reddy
Howard Univ., Washington, DC

Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 262-265, 1 fig, 1 table, 12 refs

KEY WORDS: Spacecraft, Impulse response, Multidegree of freedom systems, Reduction methods

A situation is presented in which a structure is subject to a finite impulse in all its degrees of freedom, and the participation of the various modal coordinates in dynamic response are evaluated. The dynamic response under an impulse in every degree of freedom is considered as the worst case and the modal coordinate participation is used as a criteria to eliminate some of the modes from the model. A finite element model of hoop/column antenna is considered as an example to demonstrate the reduction procedure.

85-2498

Comparative Analysis of On-Orbit Dynamic Performance of Several Large Antenna Concepts

G.C. Andersen, L.B. Garrett, R.E. Calleson
NASA Langley Res. Ctr., Hampton, VA

Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 707-722, 14 figs, 6 tables, 7 refs

KEY WORDS: Spacecraft antennas, Vibration control

With the increased accessibility to space, the utilization of space as a viable communication and earth observation medium will further develop. Many of these systems will require large space structures to meet the performance specifications. Along with the distinct advantages these structures bring, complex disadvantages also arise due to the inordinate and inherent flexible nature of the structures. Four antenna concepts -- the box truss, tetrahedral truss, wrap-radial rib, and hoop and column antenna are examined to determine the characteristic and magnitudes of the dynamic response in terms of structural displacements and member loads when subjected to various slew rate maneuvers.

85-2499

Dynamic Characteristics of Statically Determinate Space-Truss Platforms

M.S. Anderson, N.A. Nimmo
NASA Langley Res. Ctr., Hampton, VA

Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 723-728, 10 figs, 1 table, 6 refs

KEY WORDS: Spacecraft antennas, Supports, Natural frequencies, Mode shapes

The geometry of a class of statically determinate platforms is developed and vibration frequencies determined. Such configurations would allow shape control by changing member lengths to be accomplished with small forces. An additional advantage of a statically determinate structure is being free of thermal stress under any temperature distribution. Frequency comparisons between statically determinate and more conventional redundant platforms are presented. Vibration of curved platforms that could be used as antenna concepts is also investigated.

85-2500

System and Structural Dynamic Observations of a Slewed Box Truss Antenna

E.E. Bachtell, S.S. Bettadapur, L.A. Karanian, W.A. Schartel
Martin Marietta Denver Aerospace, Denver, CO
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 735-742, 11 figs, 5 tables

KEY WORDS: Spacecraft antennas, Transient response, Damping effects

A parametric study was performed to define slewing capability of large satellites and associated system changes or subsystem complexity impacts. The satellite configuration and structural arrangement from the earth observation spacecraft study was used as the baseline spacecraft. Varying slew rates, settling times, damping, maneuver frequencies, and attitude hold times provided the data required for application to a wide range of potential missions.

85-2501
Dynamics and Control of a Large Deployable Reflector
G.J. Balas, R. Shepherd
California Inst. of Technology
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 729-734, 7 figs, 2 tables, 3 refs

KEY WORDS: Spacecraft antennas, Modal damping

The problem of passively controlling structural deformations in a large deployable reflector by adding damping to the system is reviewed. The results of modeling a large deployable reflector with PATRAN-G and analyzing it with EASE2 and MSC/-NASTRAN finite element codes are reported. The first ten asymmetric and symmetric mode shapes and natural frequencies are determined.

BIOLOGICAL SYSTEMS

HUMAN

85-2502
A New Ride Quality Meter
J.J. Wood, J.D. Leatherwood
Wyle Labs.
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Soc. of Automotive Engrs., Warrendale, PA, pp 177-183, 10 figs, 13 refs

KEY WORDS: Vibration measurement, Noise measurement, Ride dynamics, Human response

An overview of the development of a NASA ride comfort model is presented. A new instrument is described, the ride quality meter, which incorporates the NASA-developed model to characterize ride comfort based upon measurement of vehicle interior noise and vibration. The meter is a portable unit which provides real-time estimates of passenger ride comfort during actual vehicle operations. It provides the first known capability to directly sum the effects of noise and vibration into a single objective comfort index.

85-2503
Some Aspects of Motorcycle Noise and Annoyance
P.M. Nelson
Transport and Road Res. Lab.
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Soc. of Automotive Engrs., Warrendale, PA, pp 185-194, 11 figs, 16 refs

KEY WORDS: Motorcycles, Traffic noise, Human response

Results of studies carried out at the TRRL on motorcycle noise and annoyance is presented. It is found that motorcycle noise is a disturbing element of traffic noise but, at present, their numbers are too low to affect measured overall traffic noise levels.

85-2504
Statistical Methods for Evaluating Truck Ride Quality Measures
J.R. Strong
Kenworth Truck Co.
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Soc. of Automotive Engineers, Warrendale, PA, pp 213-220, 12 figs, 9 refs

KEY WORDS: Trucks, Ride dynamics, Human response

Statistical methods were applied to subjective and objective ride measures used for class 8 cab-over-engine trucks. The probability of incorrectly choosing one objective ride measure over another based on its correlation coefficient with jury ratings was investigated using Monte Carlo simulation. An estimate of the standard deviation of objective ride measure error as a function of correlation coefficient was also developed.

85-2505
The Correlation of Objective Ride Measures to Subjective Jury Evaluations of Class 8 COE Vehicles
T.H. Norsworthy
Kenworth Truck Co.
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Soc. of Automotive Engineers, Warrendale, PA, pp 203-212, 18 figs, 9 refs

KEY WORDS: Trucks, Ride dynamics, Human response

Fifty-six ride tests of class 8 COE vehicles were conducted. Linear correlation was investigated between subjective jury ratings and each of 12 objective ride measures that were calculated from vertical and longitudinal cab acceleration measurements. Ninety-five percent confidence bandwidths and correlation coefficients were used to compare the correlation of each ride measure to the jury ratings.

85-2506
Experimental Determination of the Smallest Perceivable Changes in Octave Bands of Automobile Interior Noise
J. Bavonese, G.L. Gibian
General Motors Res. Labs., Warren, MI
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Soc. of Automotive Engineers, Warrendale, PA, pp 169-175, 9 figs, 5 refs

KEY WORDS: Automobiles, Interior noise, Human response

Human response to spectral changes in automobile interior noise, which characteristically has strong low-frequency content and much less high-frequency content, is investigated.

MECHANICAL COMPONENTS

ABSORBERS AND ISOLATORS

85-2507
A Method of Analysis for Unidirectional Vibration Isolators with Many Degrees of Freedom
S.A. Paipetis, A.F. Vakakis
The Univ. of Patras, Patras, Greece
J. Sound Vib., 98 (1), pp 13-23 (Jan 8, 1985), 6 figs, 1 table, 4 refs

KEY WORDS: Vibration isolators, Viscoelastic properties

An analytical procedure for the evaluation of transmissibility of an n-degree-of-freedom viscoelastic antivibration mounting is developed. The method is based on a model consisting of a number of equal masses connected with viscoelastic resilient elements with known properties. The latter can be expressed analytically through suitable rheological models or determined experimentally.

85-2508
Optimum Design of Dynamic Absorber for a

Random-Excited Machine Mounted on a Platelike Structure Foundation
K.S. Wang, Y.Z. Wang, R.T. Wang
National Cheng Kung Univ., Tainan, Taiwan, Rep. of China
Intl. J. Mech. Sci., 27 (5), pp 335-344 (1985), 6 figs, 12 refs

KEY WORDS: Dynamic absorbers, Machinery, Random excitation, Optimum design

The optimum design of a dynamic absorber for a machine mounted on a floor system is presented. The floor is considered to be a platelike structure. The transfer function is derived in closed form. Based on the band-limited white-noise excitation, the optimum tuning and damping ratios of the absorber are determined by minimizing the variance of response of the machine. Since the variance cannot be calculated directly by integrating the transfer function over the band-limited frequency range, the steepest descent method is used for determining these optimum parameters by iteration. The same procedure can be extended to deal with the cases of other multi degrees-of-freedom systems.

85-2509

Understanding Hydraulic Mounts for Improved Vehicle Noise, Vibration and Ride Qualities
W.C. Flower
Lord Corp., Erie, PA
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Soc. of Automotive Engineers, Warrendale, PA, pp 123-132, 9 figs

KEY WORDS: Engine mounts, Hydraulic systems, Ground vehicles, Vibration control, Noise reduction

It is now apparent that properly applied hydraulic mounts can significantly alter the perceived performance of current production automobiles. Benefits such as reduced interior noise and vibration levels, and improved ride, especially on moderate to rough roads, are now attainable. Such improvements require the careful design and application of hydraulic powertrain mounts, utilizing a variety of hydraulic design options, some or all of which may be appropriate to the specific vehicle application under consideration.

85-2510

An Analysis and Application of a Decoupled Engine Mount System for Idle Isolation
D.M. Ford
Vehicle Concepts Res. Lab., Ford Research Staff, Dearborn, MI
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Soc. of Automotive Engineers, Warrendale, PA, pp 133-142, 14 figs, 3 refs

KEY WORDS: Engine mounts, Vibration control

The issue of front wheel drive engine idle isolation is addressed. Criteria for design is established and an analysis of an application is presented. The approach was to model the powertrain and engine mounts as a 6 DOF lumped parameter system and decouple the five highest frequency rigid body modes from the direction of the idle torque pulses (crankshaft rotation direction).

85-2511

Desirable Structural Features for the Design of Front and Rear Underrun Bumpers for Heavy Goods Vehicles
S. Penoyre, B.S. Riley, M. Page
Transport and Road Res. Lab., Crowthorne, Berkshire, UK
Vehicle Structures, Intl. Conf., Institution of Mech.E., London, Conf. Pub. 1984-7, SAE-MEP 200, pp 139-145, 3 figs, 6 refs

KEY WORDS: Bumpers, Trucks

A review of accident situations requiring underrun bumpers is presented and the effects of car masses and structural strengths on the design of bumpers is considered. Design features discussed include: height above ground, strength to withstand full, partial offset and angled impacts, travel and force/deflection characteristics of energy absorbing bumpers and soft bumper faces to reduced pedestrian injuries.

85-2512
The Noise of Cross Groove Tire Tread Pattern Elements
L.J. Oswald, A. Arambages
General Motors Res. Labs., Warren, MI
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Soc. of Automotive Engineers, Warrendale, PA, pp 231-255, 17 figs, 9 refs

KEY WORDS: Tires, Trucks, Noise generation

This report deals specifically with the noise mechanisms of cross groove type tread elements, which includes both individual cross groove and cross lug elements. The parameters investigated include groove depth, angle of the groove relative to the sidewall, groove shape, and spacing between grooves.

85-2513
A Dynamic Tire/Soil Contact Surface Interaction Model for Aircraft Ground Operations
W.S. Pi
Northrop Corp., Hawthorne, CA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 321-329, 7 figs, 2 tables, 6 refs

KEY WORDS: Aircraft tires, Soil tire interaction

A dynamic tire/soil contact surface interaction model for aircraft ground operations is described. The formulation uses a finite element kernel function approach. It is based on the concept of the quasi-steady motion of a tired-wheel rolling at a constant speed on a linear viscoelastic layer (soil). Numerical examples were given to correlate the experimental resuks from a high flotation test program.

85-2514
Holographic Measurements and Theoretical Predictions of the Unsteady Flow in a Transonic Annular Cascade
M.R.D. Davies, P.J. Bryanston-Cross
Univ. of Cambridge, Cambridge, UK
J. Engrg. Gas Turbines Power, Trans. ASME, 107 (2), pp 450-457 (Apr 1985), 18 figs, 15 refs

KEY WORDS: Fan blades, Cascades, Holographic techniques

A series of measurements have been made on a transonic annular cascade. The cascade which represents the tip section of a compressor fan blade has an inlet Mach number of 1.18. By the use of external vibrators it is possible to vibrate the blades independently in torsion simulating different interblade phase angles to gain an understanding of shock movement and blade loading. The results presented are made over interblade phase angles of 180 and 135 deg at a blade frequency parameter of 0.1, based on chord.

85-2515
Optimization and Mechanisms of Mistuning in Cascades
E.F. Crawley, K.C. Hall
Massachusetts Inst. of Technology, Cambridge, MA
J. Engrg. Gas Turbines Power, Trans. ASME, 107 (2), pp 418-426 (Apr 1985), 13 figs, 1 table, 19 refs

KEY WORDS: Fan blades, Cascades, Tuning

An inverse design procedure has been developed for the optimum mistuning of a high bypass ratio shroudless fan. The fan is modeled as a cascade of blades, each with a single torsional degree of freedom. Linearized supersonic aerodynamic theory is used to compute the unsteady aerodynamic forces in the influence coefficient form at a typical blade section. The mistuning pattern is then numerically optimized using the method of nonlinear programming via

augmented Lagrangians. The objective of the mistuning is to achieve a specified increase in aeroelastic stability margin with a minimum amount of mistuning.

85-2516
Flutter of Swept Fan Blades
R.E. Kielb, K.R.V. Kaza
NASA Lewis Res. Ctr., Cleveland, OH
J. Engrg. Gas Turbines Power, Trans. ASME, 107 (2), pp 394-398 (Apr 1985), 9 figs, 1 table, 14 refs

KEY WORDS: Fan blades, Flutter, Geometric effects, Aerodynamic loads,

The effect of sweep on fan blade flutter is studied by applying the analytical methods developed for aeroelastic analysis of advanced turboprops. Two methods are used. The first method utilizes an approximate structural model in which the blade is represented by a swept, nonuniform beam. The second method utilizes a finite element technique to conduct modal flutter analysis.

85-2517
Some Recent Advances in the Understanding and Prediction of Turbomachine Subsonic Stall Flutter
R.M. Chi, A.V. Srinivasan
United Technologies Res. Ctr., East Hartford, CT
J. Engrg. Gas Turbines Power, Trans. ASME, 107 (2), pp 408-417 (Apr 1985), 16 figs, 24 refs

KEY WORDS: Rotor blades, Flutter

Some recent advances in the understanding and prediction of subsonic flutter of jet engine fan rotor blades are reviewed. A particular shrouded fan of advanced design is examined in the detailed technical discussion.

85-2518
Propeller Aerodynamic Performance by Vortex-Lattice Method
M. Kobayakawa, H. Onuma
Kyoto Univ., Kyoto, Japan
J. Aircraft, 22 (8), pp 649-654 (Aug 1985), 11 figs, 24 refs

KEY WORDS: Propeller blades, Aerodynamic loads

It is inappropriate to apply classical propeller theories to design an advanced turboprop (ATP). The vortex-lattice method is applied to rotating blades. Other properties characteristics of an ATP; i.e., effect of displacement velocities, interference effect between blades, and effect of flow deflection by a spinner and nacelle, are introduced into the calculations. Powers, thrusts, and efficiencies of two kinds of ATP, SR-1 and SR-3, are obtained and compared with experimental values.

85-2519
Application of the Finite-State Arbitrary-Motion Aerodynamics to Rotor Blade Aeroelastic Response and Stability in Hover and Forward Flight
M.A.H. Dinyavari, P.P. Friedmann
Univ. of California, Los Angeles, CA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 522-535, 16 figs, 16 refs

KEY WORDS: Helicopters, Propeller blades, Aerodynamic loads

The influence of finite-state arbitrary-motion time-domain aerodynamics on rotor blade aeroelastic stability in hover and forward flight is illustrated. The essential ingredients of the generalized Greenberg type time-domain unsteady aerodynamics are presented and incorporated in a coupled nonlinear flap-lag analysis. Aeroelastic stability boundaries for both hover and forward flight are obtained using both arbitrary-motion time-domain aerodynamics and quasisteady aerodynamics.

85-2520
Effects of Mistuning on the Forced Vibration of Bladed Disks in Subsonic Flow

P.W. Whaley, J.C. MacBain
Univ. of Nebraska
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 490-499, 16 figs, 1 table, 12 refs

KEY WORDS: Bladed disks, Tuning, Forced vibrations

Forced vibration as a function of mistuning is investigated for aeroelastic coupling and subsonic flow. Under certain aerodynamic conditions and for certain engine orders and mistuning, the forced vibration has been demonstrated to increase by more than an order of magnitude.

BEARINGS

85-2521
An Influence of Fluid Inertia Forces on the Dynamic Characteristics of Tilting-pad Journal Bearings in Turbulent Flow
H. Hashimoto, S. Wada, S. Yamamoto
Tokai Univ., Hiratsuka-shi, Kanagawa, Japan
Bull. JSME, 28 (239), pp 919-923 (May 1985), 7 figs, 4 refs

KEY WORDS: Journal bearings, Tilt pad bearings, Fluid inertia forces, Turbulence

An influence of fluid inertia forces on the dynamic characteristics of tilting-pad journal bearings in turbulent flow is investigated theoretically. Applying the generalized turbulent lubrication equation with inertia effects to the centrally pivoted 2-pads journal bearings, the dynamic oil film forces are obtained.

85-2522
A Refined Numerical Solution for the Hydrodynamic Lubrication of Finite Porous Journal Bearings
B.R. Reason, A.H. Siew
Cranfield Inst. of Technology, Cranfield, Bedford, UK
IMechE, Proc., 199 (C2), pp 85-93 (1985), 8 figs, 7 refs

KEY WORDS: Journal bearings, Hydrodynamic lubrication

A refined numerical solution for the hydrodynamic performance of finite porous journal bearings is presented. The solution takes into account the curvature of the bearing wall, interfacial slip of the fluid across the pore mouths, and employs the Reynolds boundary conditions at the oil film extremities.

85-2523
On the Radial Vibration of Ball Bearings (Computer Simulation)
S. Fukata, E.H. Gad, T. Kondou, T. Ayabe
Kyushu Univ., 6-10-1 Hakozaki, Higashi-ku, Fukuoka-shi, Japan
Bull. JSME, 28 (239), pp 899-904 (May 1985), 8 figs, 2 tables, 7 refs

KEY WORDS: Ball bearings, Radial vibrations, Computerized simulation

Computer simulation is used to analyze the radial vibration of ball bearings in order to overcome the experimental and theoretical difficulties: the experimental difficulties are due to the complicated interaction of the dominant factors while the theoretical difficulties are due to the nonlinear spring behavior and time-dependent excitation of ball bearings.

BELTS

85-2524
Design of Belt-Tensioner Systems for Dynamic Stability
A.G. Ulsoy, J.E. Whitesell, M.D. Hooven
Univ. of Michigan, Ann Arbor, MI
J. Vib., Acoust., Stress Rel. Des., Trans. ASME, 107 (3), pp 282-290 (July 1985), 14 figs, 1 table, 15 refs

KEY WORDS: Belt drives, Dynamic stability

Several potential instability mechanisms for belt-tensioner systems are described and a

design methodology is presented to ensure good dynamic performance of such systems. A mathematical model of the belt-tensioner system, and numerical solution methods, are utilized to develop a computer-aided design procedure. Numerical results, and confirming experimental data, are presented for a particular automotive belt-tensioner system.

FASTENERS

85-2525

An Assessment of the Impact Performance of Bonded Joints for Use in High Energy Absorbing Structures

J.A. Harris, R.D. Adams
Univ. of Bristol, UK
IMechE, Proc. 199 (C2), pp 121-131 (1985), 15 figs, 2 tables, 8 refs

KEY WORDS: Joints, Bonded structures, Energy absorption

Using an instrumented impact test, the strength and energy absorption of bonded single lap joints have been measured for single lap joints with four epoxy adhesives and three aluminium alloy adherends. The effect of loading rate on bonded joint strength has been analyzed using a nonlinear finite element method, from which predictions of joint strength in keeping with the experimental results have been obtained. Crush tests carried out on open-ended cylinders have been used to simulate the impact behavior of an energy absorbing structure.

85-2526

A Design Method for Reducing the Effects of Clearances at Revolute Joints

J.K. Shin, B.M. Kwak
Korea Advanced Inst. of Science and Technology, Seoul, Korea
IMechE, Proc., 199 (C2), pp 153-158 (1985), 8 figs, 9 refs

KEY WORDS: Mechanisms, Joints, Clearance effects, Design Techniques

A method for designing a mechanism which is free of contact loss in clearance connections is developed. Only revolute joints are considered as possible clearance joints. This general theory was applied to a slider crank mechanism and it is shown that designing a perfect joint is theoretically possible through balancing by a nonlinear spring. This technique gives a practical guide for balancing a mechanism with linear springs to reduce the possibility of contact loss in clearance joints.

85-2527

Joint Deformations and Stresses of Commercial Vehicle Frame Under Torsion

H.J. Beermann
Technical Univ. of Braunschweig, W. Germany
Vehicle Structures, Intl. Conf. Institution of Mech.E, London, Conf. Pub. 1984-7, SAE-MEP 200, pp 171-180, 8 figs, 1 table, 10 refs

KEY WORDS: Joint stiffness, Cargo vehicles, Nonlinear theories

The flexibility of joints in commercial vehicle frames is shown; this is considered in frame analysis. Special problems arising in stress calculation are demonstrated. Nonlinear behavior is essential to dynamic analysis.

85-2528

Stochastic Crack Propagation in Fastener Holes

J.N. Yang, S.D. Manning, J.L. Rudd, W.H. Hsi
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 1, pp 225-233, 15 figs, 1 table, 26 refs

KEY WORDS: Fasteners, Fatigue life, Crack propagation

A simple crack growth rate-based stochastic model for fatigue crack propagation in fastener holes under spectrum loadings is

investigated. With available fractographic data in the very small crack size region, i.e., 0.004 to 0.07 inches, the model was demonstrated to be very good. Laboratory tests were conducted using wide fastener hole specimens to obtain fractographic data covering the small and large crack size regions in both laboratory air and a corrosive environment.

LINKAGES

85-2529
An Experimental Investigation into the Dynamic Behaviour of Revolute Joints with Varying Degrees of Clearance
R.S. Haines
NEI Reyrolle Power Switchgear, Hebburn, Tyne & Wear, NE31 1 UP, UK
Mech. Mach. Theory, 20 (3), pp 221-231 (1985), 9 figs, 1 table, 18 refs

KEY WORDS: Joints, Linkages, Clearance effects, Experimental data

Under static loads, the deflections associated with contact elasticity in a dry journal bearing were found to be much greater and less linear than predicted. Under a suddenly reversed uniaxial load, the air film was found to cause a dramatic change of behavior at reduced clearances. Under a load variation representative of that at a linkage mechanism joint, the behavior with the greatest clearance gave some support to an approximate theory published by the author.

VALVES

85-2530
Noise and Vibration Induced by Throttling of High Pressure Compressible Fluid (Part 1 — Characteristics of Noise and Vibration Generated by Cage-guided Control Valve)
R. Okutsu, E. Outa, S. Kuramochi, T. Machiyama
Waseda Univ., Okubo 3-4-1, Shinjuku, Tokyo, Japan
Bull. JSME, 28 (239), pp 837-845 (May 1985), 20 figs, 1 table, 16 refs

KEY WORDS: Valves, Fluid-induced excitation

Features of noise and vibration generated by a cage-guided control valve are discussed. In this type of valve, kinetic energy of the throttled jets is dissipated by mutual collision of the jets themselves. The pressure reduction process is made considerably smooth, and the noise level becomes lower than that of a freely expanding jet.

STRUCTURAL COMPONENTS

CABLES

85-2531
Karman Vortex Shedding, Friend or Foe of the Structural Dynamicist?
L.E. Ericsson
Lockheed Missiles & Space Co., Inc., Sunnyvale, CA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 238-250, 20 figs, 26 refs

KEY WORDS: Cables, Vortex shedding, Galloping

An analysis including the coupling between Karman vortex shedding and body motion has been performed for rectangular cross-sections. The analysis shows how the Karman vortex shedding can eliminate the large amplitude response for the so called galloping cable over large reduced velocity regions.

85-2532
The Phenomenon of Damping in Stranded Cables

I. Pivovarov, O.G. Vinogradov
Univ. of Calgary, Calgary, Alberta, Canada
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 232-237, 4 figs, 2 tables, 6 refs

KEY WORDS: Cables, Damping coefficients, Hysteretic damping

Hysteretic loops and frequency response curves of a cantilever cable having a concentrated mass at the free end are investigated experimentally and modeled mathematically. Experimental observations show that hysteretic loops are frequency and amplitude dependent. To describe different damping mechanisms two nonlinear mathematical models are postulated: the first model takes into account the nonlinear stiffness and viscous and Coulomb type of damping, the second model, in addition to viscous damping, includes the Davidenkov's description of a hysteretic loop with sharp edges. These two models describe hysteretic loops with different shapes.

BEAMS

85-2533
Impact of a Prestressed Beam
D.P. Thambiratnam
National Univ. of Singapore, Kent Ridge, Singapore 0511
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 363-368, 3 figs, 2 tables, 9 refs

KEY WORDS: Beams, Prestressed structures, Transient response, Wavefront expansion method

The response of a prestressed beam subjected to an end impact is treated using the method of wavefront expansion. The impact can be prescribed in the form of stress, strain, velocity or acceleration boundary conditions. The Timoshenko equations, modified to include the initial stress, are used to model the beam. The analysis is based on the concept of a wave as a carrier of discontinuities in the field variables and their derivatives.

85-2534
Optimal Design of a Vibrating Beam with Coupled Bending and Torsion
S. Hanagud, C.V. Smith, Jr., A. Chattopadhyay
Georgia Inst. of Technology, Atlanta, GA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 1, pp 780-792, 7 figs, 24 refs

KEY WORDS: Beams, Coupled response, Flexural vibration, Torsional vibration, Fundamental frequencies

The problem of maximizing the fundamental frequency of a thin walled beam with coupled bending and torsional modes is studied. An optimality criterion approach is used to locate stationary values of an appropriate objective function subject to constraints. Optimal designs with and without coupling are discussed.

85-2535
Vibrations of a Beam and a Moving Load with Sprung and Unsprung Masses
M. Yoshizawa, T. Takizawa, Y. Tsujioka
Keio Univ. 3-14-1 Hiyoshi, Kohoku-ku, Yokohama, Japan
Bull. JSME, 28 (239), pp 911-918 (May 1985), 10 figs 8 refs

KEY WORDS: Beams, Moving loads

This paper deals with the vibration of a simple beam under the action of a moving load, the two masses connected with a linear spring. It is shown that the vibration of this system consists of two modes, each of which has a time-dependent natural frequency. Using the above analytical result, the lateral vibration of the beam and the vertical oscillation of the sprung mass are shown for different ratios between the

natural frequencies of the moving load and the beam.

85-2536
Free Vibrations of Thin-Walled Pretwisted Beams under Axial Loadings (1st Report, Governing Equations of Motion)
T. Tsuiji
Nagasaki Univ., Nagasaki, Japan
Bull. JSME, 28 (239), pp 894-898 (May 1985), 5 figs, 7 refs

KEY WORDS: Beams, Initial deformation effects, Coupled response, Torsional vibrations, Longitudinal vibrations

The derivation of the equations governing the response of a thin-walled pretwisted beam under axial loadings is presented. The equations of motion, taking into account the coupling effects of torsional and longitudinal vibrations and deformations due to axial loading, are derived. Frequency parameters of the coupled torsional and longitudinal vibrations for pretwisted cantilever beams of thin rectangular cross-section are obtained under axial tensile forces.

85-2537
Penalty Finite Element Models for Nonlinear Dynamic Analysis
A.K. Noor, J.M. Peters
NASA Langley Res. Ctr., Hampton, VA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 369-378, 10 figs, 2 tables, 18 refs

KEY WORDS: Curved beams, Finite element technique

A simple penalty finite element formulation is presented for the large-rotation dynamic analysis of curved beams. The analytical formulation is based on a form of Reissner's large-deformation theory with the effects of transverse shear deformation and the extensibility of the centerline constrained through the use of the penalty method. Reduced integration is used in evaluating the elemental stiffness arrays and the temporal integration is performed by using Newmark's method. Numerical results are presented to demonstrate the effectiveness of the finite elements developed.

85-2538
An Improved Finite Difference Analysis of Uncoupled Vibrations of Cantilevered Beams
K.B. Subrahmanyam, A.W. Leissa
Ohio State Univ., Columbus, OH
J. Sound Vib., 98 (1), pp 1-11 (Jan 8, 1985), 3 tables, 11 refs

KEY WORDS: Cantilever beams, Natural frequencies, Mode shapes, Finite difference technique

Natural frequencies and mode shapes of uniform cantilever beams are obtained with use of the first and second order central difference schemes. It is observed that the improved finite difference scheme with second order central differences produces the natural frequencies and characteristic functions, with a rapid convergence as compared to the conventional approach of using the first order central differences. The present approach facilitates a direct determination of the dynamic characteristics of beams without any necessity of extrapolations of the results or application of iterative procedures for improving the accuracy.

MEMBRANES, FILMS, AND WEBS

85-2539
Impact of Spherical Membranes Partially Filled with Water and Air
C.W. Bert, D.R. Bert
The Univ. of Oklahoma, Norman, OK
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 357-362, 4 figs, 3 tables, 10 refs

KEY WORDS: Membranes, Fluid-filled containers, Impact response

Experimental results on three series of impact experiments on flexible spherical membranes (soccer balls) are presented. Some appropriate simple analyses are also presented.

PANELS

85-2540
Modal Response and Noise Transmission of Composite Panels
F.W. Grosveld, V.L. Metcalf
The Bionetics Corp., Hampton, VA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 617-627, 15 figs, 5 tables, 20 refs

KEY WORDS: Panels, Fiber composites, Noise transmission, Modal analysis

Noise transmission through flat, rectangular, fiber reinforced composite panels has been investigated analytically and experimentally. Utilizing modal decomposition, theoretical solutions of the governing *differential* equation of motion were obtained for a specially orthotropic composite panel. Experimental modal analysis was performed to extract the modal frequencies and damping of several composite panels. These modal parameters then were used to predict the field-incidence transmission loss.

85-2541
The Measurement of Acoustic Properties of Limited Size Panels by Use of a Parametric Source
V.F. Humphrey
Univ. of Bath, Bath BA2 7AY, UK
J. Sound Vib., 98 (1), pp 67-81 (Jan 8, 1985), 15 figs, 16 refs

KEY WORDS: Panels, Submerged structures, Acoustic properties

A method of measuring the acoustic properties of limited size panels immersed in water, with a truncated parametric array used as the acoustic source, is described. The insertion loss and reflection loss of thin metallic panels, typically 0-45 m square, were measured at normal incidence by using this technique. Results were obtained for a wide range of frequencies (10 to 100 kHz) and were found to be in good agreement with the theoretical predictions for plane waves.

PLATES

85-2542
Effects of Transverse Shearing on Cylindrical Bending, Vibration, and Buckling of Laminated Plates
M. Stein, D.C. Jegley
NASA Langley Research Ctr., Hampton, VA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, FL, spons. AIAA/ASME/-ASCE/AHS, Part 1, pp 505-515, 10 figs, 11 refs

KEY WORDS: Plates, Beams, Transverse shear deformation effects, Layered materials

The displacements for cylindrical bending and stretching of laminated and thick plates are expressed through-the-thickness by a few algebraic terms and a complete set of trigonometric terms. Only a few terms of this series are needed to get sufficiently accurate results for laminated and thick plates. Equations of equilibrium based on a sufficient number of terms of this series for displacements are determined using variational theorems from three-dimensional elasticity.

85-2543
Optimal Design of Stiffened Laminated Composite Plates with Frequency Constraints
L.C. Mesquita, M.P. Kamat
Virginia Polytechnic Inst. and State Univ., Blacksburg, VA

Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 1, pp 825-833, 2 figs, 4 tables, 10 refs

KEY WORDS: Plates, Layered materials, Fundamental frequencies

The authors consider the problem of maximization of the fundamental frequency of a stiffened laminated composite plate of a given configuration subject to an upper bound on its total weight, and to the requirement that the first few frequencies be separated from the first frequency by prescribed ratios.

85-2544

The Vibration Analysis of Carbon Fibre - Glass Fibre Sandwich Hybrid Composite Plates

D.X. Lin, R.G. Ni, R.D. Adams
Shaanxi Inst. of Mechanical Engrg. Xian, China

Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 120-125, 1 fig, 4 tables, 5 refs

KEY WORDS: Plates, Composite materials, Finite element technique, Damping coefficients

A finite element technique using a damped element and allowing for shear deformation is used for the prediction of the vibrational characteristics of hybrid carbon/glass fiber-reinforced plastics composite plates. The theory is briefly presented and assessed by comparing with experimental results on natural frequencies, mode shapes and damping values.

85-2545

Multiple Mode Nonlinear Dynamic Analysis of Composite Moderately Thick Elliptical Plates

M. Sathyamoorthy
Clarkson Univ., Potsdam, NY 13676

Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 201-207, 4 figs, 3 tables, 12 refs

KEY WORDS: Plates, Flexural vibration, Transverse shear deformation effects, Rotatory inertia effects

A theoretical investigation of large amplitude flexural vibration of clamped, moderately thick composite elliptical plates is carried out. Von Karman-type field equations which are given in terms of the three displacement components of the plate are used. Included in these field equations are the effects of transverse shear deformation and rotatory inertia such that they can readily be used for moderately thick plates of any plate geometry. Solutions to these governing equations are obtained by using a multiple-mode approach and employing Galerkin's method and the numerical Runge-Kutta procedure.

85-2546

Moving Harmonic Load on a Prestressed Thick Strip Plate

S. Chonan, S. Sugawara
Tohoku Univ., Sendai, Japan

J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 107 (3), pp 291-295 (July 1985), 7 figs, 12 refs

KEY WORDS: Plates, Moving loads, Harmonic excitation, Rotatory inertia effects, Transverse shear deformation effects

The steady-state response of an initially stressed, thick strip plate subjected to a sinusoidally oscillating moving line load is studied. The problem is studied on the basis of a thick plate theory which takes into account the effect of the second-order increments of the normal stresses as well as the effect of rotatory inertia and shear deformations. Critical speed for which a resonance effect occurs in the system is obtained.

85-2547

Aero/Hydrodynamic Stability of Elastically

Supported Plates in Narrow Channels with Upstream Barriers Preventing Flow Redistribution
W.D. Mark
Bolt Beranek and Newman, Inc., Cambridge, MA
J. Vib., Acoust., Stress Rel. Des., Trans. ASME, 107 (3), pp 319-328 (July 1985), 7 figs, 22 refs

KEY WORDS: Plates, Elastic supports, Fluid induced excitation

The dynamic stability of an elastically supported finite rigid plate centered in a straight narrow channel with incompressible flow on both sides of the plate and an upstream barrier preventing flow redistribution is analyzed. An integral equation for the pressure in a narrow channel having arbitrary small time-dependent boundary displacements is formulated and solved for the pressure distribution in terms of the boundary motion. The resulting expression for the time-dependent pressure distribution is combined with the plate differential equations of motion to yield the homogeneous equations of motion of the plate-fluid autonomous system.

85-2548
Free Vibration of Polar-Orthotropic Sector Plates Resting on Point Supports
Y. Narita
Hokkaido Inst. of Technology, Sapporo 061-24, Japan
J. Vib., Acoust., Stress Rel. Des., Trans. ASME, 107 (3), pp 334-338 (July 1985), 5 figs, 3 tables, 16 refs

KEY WORDS: Plates, Ritz method

An accurate Ritz solution for the free vibration of point-supported annular sector plates of polar orthotropy is presented. A double power series function is used to represent deflection of the plate, with Lagrange multipliers to impose the constraint conditions. To establish accuracy of the approach, the frequency parameters of sector plate with some supporting points distributed along the boundary are compared to those of a uniformly simply supported plate.

85-2549
Free Vibration of Stiffened Rectangular Plates Using Green's Functions and Integral Equations
J.W. Nicholson
Univ. of Illinois, Urbana-Champaign, IL
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/ASME/ASCE/AHS, Part 2, pp 184-191, 8 figs, 1 table, 16 refs

KEY WORDS: Rectangular plates, Green function, Fredholm equation, Natural frequencies, Mode shapes

A new method for the free vibration analysis of stiffened rectangular plates based on the use of Green's functions and the solution of a system of Fredholm integral equations of the second kind is demonstrated. The lateral forces of constraint and the twisting moments of constraint between the plate and beam-stiffeners is accounted for. For plates with simply supported edges perpendicular to the stiffeners the integral equations are solved exactly to yield the characteristic equations for the natural frequencies.

85-2550
Finite Element Nonlinear Forced Vibration Analysis of Symmetrically Laminated Composite Rectangular Plates
Chuh Mei, C.K. Chiang
Old Dominion Univ., Norfolk, VA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/ASME/ASCE/AHS, Part 2, pp 208-218, 3 figs, 5 tables, 18 refs

KEY WORDS: Rectangular plates, Layered materials, Forced vibration, Finite element technique

A finite element formulation is presented for determining the large amplitude,steady-state, forced vibrational response of symmetrically laminated composite rectangular thin plates. Nonlinear stiffness and harmonic force matrices of a rectangular symmetrically laminated composite plate element are developed for nonlinear forced

vibration analysis. Inplane deformation and inertia are both included in the formulation.

85-2551
Linear and Nonlinear Vibrations Caused by Periodic Impulses
E. Suhir
AT&T Bell Labs., Murray Hill, NJ
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 224-231, 5 figs, 10 refs

KEY WORDS: Rectangular plates, Transient vibrations, Periodic vibrations, Period excitation

Linear and nonlinear steady-state and transient vibrations caused by periodic impulses are discussed. Deterministic and probabilistic approaches are examined, and the case of the dynamic response of an elongated rectangular plate is used to illustrate the two techniques.

85-2552
Analysis of Vibrating Orthotropic Rectangular Plates by a Modified Rayleigh-Ritz Method
P.A.A. Laura, J.P. Viazzi
Inst. of Applied Mechanics, Puerto Belgrano Naval Base, 8111 Argentina
Ocean Engrg., 12 (1), pp 17-24 (1985), 4 figs, 2 tables, 4 refs

KEY WORDS: Rectangular plates, Orthotropism, Rayleigh-Ritz method

The title problem is solved in the case where the plate is clamped along two adjacent edges while the remaining are free. A mass is rigidly attached to the plate. The value of the fundamental frequency coefficient is conveniently minimized by means of Schmidt's approach. The methodology presented herewith can be extended without formal difficulties to other vibrating systems.

85-2553
The Natural Frequencies of In-Plane Stressed Rectangular Plates
S. Ilanko, S.C. Tillman
Univ. of Manchester, Manchester, UK
J. Sound Vib., 98 (1), pp 25-34 (Jan 8, 1985), 7 figs, 4 tables, 17 refs

KEY WORDS: Rectangular plates, Natural frequencies, Finite difference technique, Computer programs

The stress distributions in some practical in-plane loaded plates have been obtained either directly via strain gauges or indirectly from the measurement of transverse deflections or initial imperfection profiles. These stress distributions have been incorporated into a purpose-written finite difference computer program set up to evaluate the natural frequencies of the plates. A comparison has been made between these frequencies and those measured directly in the laboratory.

85-2554
Finite Element Method for Nonlinear Forced Vibrations of Circular Plates
K. Decha-Umphai
Old Dominion Univ., Norfolk, VA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 192-200, 9 figs, 4 tables, 13 refs

KEY WORDS: Circular plates, Finite element technique, Nonlinear theories

Geometric nonlinearities for large amplitude free and forced vibrations of circular plates are investigated. Inplane displacement and inertia are included in the formation. The finite element method is used. Harmonic force matrix for nonlinear forced vibration analysis is introduced and derived. Various out-of-plane and inplane boundary conditions are considered. The relations of amplitude - frequency ratio for different boundary conditions and various loads conditions are presented.

85-2555
Experimental Study of Free Vibration of Circular Plates with a Straight Eccentric Narrow Slit
K. Maruyama, O. Ichinomiya
Hokkaido Inst. of Technology, Hokkaido, 061-24, Japan
Bull. JSME, 28 (239), pp 890-893 (May 1985), 3 figs, 1 table, 2 refs

KEY WORDS: Circular plates, Mode shapes, Flexural vibrations, Natural frequency, Discontinuity-containing media

The real time technique of time averaged holographic interferometry has been applied to determine the natural frequencies, and the corresponding mode shapes for the transverse vibrations of clamped circular plates with a straight eccentric narrow slit. Eccentricity and length of the slit have been selected as parameters, while width of the slit has been kept constant. The first six natural modes arae discussed.

85-2556
On Squeeze Film of a Curved Circular Plate
E. Hasegawa
Keio Univ., Yokohama 223, Japan
Bull. JSME, 28 (239), pp 951-958 (May 1985), 6 figs, 6 refs

KEY WORDS: Curved plates, Squeeze-film dampers

The problem of a squeeze film between a curved circular plate and a plane wall is studied theoretically. The shape of the curved circular plate is assumed to be axisymmetric; that is, to be expressed by a function of only the radius coordinate. A perturbation solution is found in powers of ratio of the gap to the radius. The equation governing the gap is derived for a curved disk with any shape. The properties of the squeeze film are clarified through the forge-gap relation, the critical external force, the inertia effect and the pressure distribution.

85-2557
Flutter Analysis of Cantilevered Quadrilateral Plates
R.S. Srinivasan, B.J.C. Babu
FRP Res. Ctr., Indian Inst. of Technology, Madras 600 036, India
J. Sound Vib., 98 (1), pp 45-53 (Jan 8, 1985) 2 figs, 3 tables, 11 refs

KEY WORDS: Cantilevered plates, Flutter

The title problem is solved by using a numerical method involving an integral equation technique and a normal mode method. Linear plate theory has been used for computing the strain and kinetic energy energy of the plate. Piston theory has been used to describe the aerodynamic pressure distribution Numerical work has been done and convergence of the solution has been studied.

SHELLS

85-2558
Approach to Interior Noise Control Part II: Self-Supporting Damped Interior Shell
C.I. Holmer
Cabot Corp., Indianapolis, IN
J. Aircraft, 22 (8), pp 729-733 (Aug 1985) 4 figs, 6 refs

KEY WORDS: Shells, Noise reduction, Structure borne noise, Interior noise, Aircraft noise

A companion paper present theoretical and experimental data identifying the significance of panel critical frequency and structural damping in controlling trim panel dynamic response from excitation at attachment points. This paper explores a logical extension to the trim panel system. The shell presents several desirable nonacoustic properties that may offer design or construction economies. Of concern here is the design considerations that can turn potential acoustic problems into significant advantages.

85-2559
Three Dimensional Nonlinear Dynamic Finite Element Analysis for the Response of a Thick Laminated Shell to Impact Loads

R.E. McCarty, D.E. Trudan, A.D. Davis
Air Force Wright Aeronautical Labs., Wright-Patterson Air Force Base, OH
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 341-356, 26 figs, 2 tables, 30 refs

KEY WORDS: Shells, Layered materials, Impact response, Aircraft windows, Bird impact

The response of the T-38 aircraft student windshield structural assembly to bird impact loading is simulated using the MAGNA (materially and geometrically nonlinear analysis) three-dimensional nonlinear finite element analysis system. User subroutines are used to couple the mathematical definition of the bird impact pressures to the computed response of the aircraft windshield assembly. These pressures are applied to the faces of finite elements lying within the bird impact footprint on the surface of the windshield. The analysis problem is characterized by severe material and geometric nonlinearities as well as significant fluid/solid interaction (load/response coupling).

85-2560
The Effect of Source Location on the Structural-Acoustic Interaction of an Infinite Elastic Shell
J.J. Kelly, C.R. Fuller
Old Dominion Univ., Norfolk, VA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 609-616, 14 figs, 7 refs

KEY WORDS: Shells, Acoustic response

The response of an infinite elastic shell to simple acoustic sources (monopole and dipole) is investigated. This simplified model is considered in order to gain insight into the characteristics of aircraft interior noise. The shell represents the aircraft fuselage and the sources are due to the propellor. The location of the source with respect to the cylinder and how this affects acoustic line power, intensity flow into the sheil and internal sound pressure is analyzed.

85-2561
Response of Double Wall Composite Shells
R. Vaicaitis, D.A. Bofilios
Columbia Univ., New York, NY
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 110-119, 12 figs, 18 refs

KEY WORDS: Cylindrical shells, Layered materials, Viscoelastic core-containing materials, Natural frequencies, Power spectral densities

An analytical study of double wall laminate cylindrical shell response to random loads is presented. A soft viscoelastic core with dilatational modes included is used. The theory of laminate shells is simplified by assumptions similar to those in the Donnell-Mushtari development for isotropic shells. Modal solutions of simply supported shells are obtained. Modal frequencies and deflection response spectral densities are determined.

PIPES AND TUBES

85-2562
Wave Forces on Large Offshore Pipelines
N.J. Shankar, H. Raman, V. Sundar
National Univ. of Singapore, Kent Ridge, Singapore
Ocean Engrg., 12 (2), pp 99-115 (1985), 11 figs, 14 refs

KEY WORDS: Pipelines, Offshore structures, Wave forces, Experimental data

A laboratory investigation of wave forces induced by a regular train of waves on a large pipeline resting on a bed and at various clearances from the bed is presented. A simple unseparated flow model

based on potential flow theory and Morison's equation is presented for evaluating the maximum forces on the pipeline. The experimental results are compared with the theoretical results and data from existing literature.

DYNAMIC ENVIRONMENT

ACOUSTIC EXCITATION

85-2563
An Integral Equation Method for Predicting Acoustic Emission within Enclosures
D.T.L Francis, M.M. Sadek
City of Birmingham Polytechnic
IMechE, Proc., 199 (C2), pp 133-137 (1985), 2 figs, 10 refs

KEY WORDS: Noise generation, Acoustic emission, Enclosures, Prediction techniques

A method is presented for calculating the acoustic emission of a vibrating body within an enclosure whose surface has known absorption characteristics. It is based on a numerical solution of the Helmholtz integral equation. Solutions are given for the case of a pulsating sphere within a sphere, and good agreement with the exact analytical solution is reported. The method is of value for small and medium scale problems at lower frequencies where traditional techniques are less reliable.

85-2564
On the Effect of Terrain Profile on Sound Propagation Outdoors
K.B. Rasmussen
Danish Acoustical Inst., Technical Univ. of Denmark, Lyngby, Denmark
J. Sound Vib., 98 (1), pp 35-44 (Jan 8, 1985) 13 figs, 21 refs

KEY WORDS: Sound waves, Wave propagation, Noise barriers

Various models describing outdoor sound propagation over wedge barriers and three-sided barriers are described. The theoretical results are compared with measured data for sound propagation over grass-covered earth berms from a loundspeaker source. Calculated and measured results for a road traffic noise situation involving an earth berm are also presented.

85-2565
Review of Research on Structureborne Noise
R. Vaicaitis, J.S. Mixson
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, FL, spons. AIAA/ASME/-ASCE/AHS, Part 2, pp 587-601, 16 figs, 150 refs

KEY WORDS: Structural-borne noise, Aircraft noise

Publications on the topic of structure-borne noise are reviewed. Recent accomplishments, including representative results, are presented for aircraft, rotorcraft, space structures, automotive vehicles, ship and building technology. Special attention is given to propeller-driven aircraft.

85-2566
Theory and Practice in Exhaust System Design
L.J. Eriksson, P.T. Thawani
Nelson Industries, Inc.
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Society of Automotive Engineers, Warrendale, PA, pp 257-266, 10 figs, 20 refs

KEY WORDS: Exhaust systems, Mufflers

A number of theoretical results related to exhaust systems is presented and some of their practical implications for design are discussed. A brief review is included of exhaust system theory as well as experimental results obtained on actual units. The connection between theory and practice

is then analyzed for reactive effects, resistive effects, and engine interactions. The emphasis throughout the paper is on the use of theory to guide practical design.

85-2567
A Systematic Approach to the Analysis of Brake Noise
H.W. Schwartz, W.D. Hays, Jr., J.H. Tarter
Allied Automotive
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Society of Automotive Engineers, Warrendale, PA, pp 267-275, 5 figs, 4 refs

KEY WORDS: Brakes, Noise generation, Noise reduction

A systematic approach to the control of disc brake noise is suggested. Test methods are described, based on the use of modern techniques, along with approaches to the design of quiet brakes which consider not only friction material, but also friction pad assembly and other components.

85-2568
On the Long Range Propagation of Sound Over Irregular Terrain
M.S. Howe
Bolt Beranek and Newman Inc., Cambridge, MA
J. Sound Vib., 98 (1), pp 83-94 (Jan 8, 1985) 3 figs, 34 refs

KEY WORDS: Sound waves, Wave propagation, Surface roughness

The theory of sound propagation over randomly irregular, normally plane terrain of finite impedance is discussed. The analysis is an extension of the theory of coherent scatter originally proposed by Biot for an irregular rigid surface. It combines Biot's approach, wherein the surface irregularities are modeled by a homogeneous distribution of hemispherical bosses, with more conventional analysis in which the ground is modeled as a smooth plane of finite impedance.

85-2569
Diffraction Sound Field by a Circular Aperture in the Surface of a Rectangular Enclosure
K. Nishida, A. Maruyama
Muroran Inst. of Tech., Muroran, Hokkaido, Japan
Bull. JSME, 28 (239), pp 931-936 (May 1985) 4 figs, 6 refs

KEY WORDS: Sound waves, Wave diffraction

The diffraction sound field generated by a circular aperture in the surface of a rectangular enclosure containing a sound source inside is theoretically and experimentally investigated. The applicability of Pierce's approximate solution of sound diffraction by a three-sided semi-infinite wall to finite three dimensional bodies is examined. The properties of diffraction sound field around the enclosure are obtained through sound visualization method.

85-2570
The Performance of Jet Noise Suppression Devices for Industrial Applications
M.D. Dahl, O.H. McDaniel
NASA Lewis Res. Ctr., Cleveland, OH
J. Vib., Acoust., Stress Rel. Des., Trans. ASME, 107 (3), pp 303-309 (July 1985) 6 figs, 15 refs

KEY WORDS: Jet noise, Noise reduction, Exhaust noise, Silencers

Commercially available jet noise suppression devices were tested to determine their noise reducing characteristics compared to an open pipe. Both exhaust silencers and ejector nozzles were measured for sound power level and mass flow rate. In addition for ejector nozzles, the added noise from a jet impinging on a flat plate was measured.

SHOCK EXCITATION

85-2571
Shock Associated Noise of Inverted-Profile Coannular Jets, Part I: Experiments

H.K. Tanna, W.H. Brown, C.K.W. Tam
Lockheed-Georgia Co., Marietta, GA 30063
J. Sound Vib., 98 (1), pp 95-113 (Jan 8, 1985), 12 figs, 2 tables, 17 refs

KEY WORDS: Shock waves, Noise generation

The reduction of shock-associated noise in inverted-velocity-profile coannular jets is quantified and explained. Extensive optical and acoustic measurements for a suitable range of outer and inner stream pressure ratio combinations are conducted. The measured noise results are interpreted with the aid of new theoretical models.

85-2572
Shock Associated Noise of Inverted-Profile Coannular Jets, Part II: Condition for Minimum Noise
C.K.W. Tam, H.K. Tanna
Lockheed-Georgia Co., Marietta, GA 30063
J. Sound Vib., 98 (1), pp 115-125 (Jan 8, 1985), 4 figs, 1 table, 10 refs

KEY WORDS: Shock waves, Noise generation

An experimental and theoretical investigation of shock-associated noise of inverted-profile coannular jets is described. For a fixed fan-stream Mach number, it is observed that the shock-associated noise often drops suddenly to a minimum as the reservoir pressure of the primary jet increases. When this happens, the almost periodic shock cell structure of the fan stream is found to nearly completely disappear.

85-2573
Shock Associated Noise of Inverted-Profile Coannular Jets, Part III: Shock Structure and Noise Characteristics
C.K.W. Tam, H.K. Tanna
Lockheed-Georgia Co., Marietta, GA
J. Sound Vib., 98 (1), pp 127-145 (Jan 8, 1985), 8 figs, 1 table, 9 refs

KEY WORDS: Shock waves, Noise generation

The basic objective of the work described is to obtain an understanding of the characteristics of shock associated noise from inverted-profile coannular jets in terms of the properties of the shock cell structure and the jet flow. To achieve this, a first-order shock-cell model is developed. Based on the concept that shock-associated noise is generated by the weak interaction between the large-scale turbulent structures in the mixing layers of the jet and the repetitive shock-cell system, formulae for the peak frequencies as well as noise intensity scaling are derived.

VIBRATION EXCITATION

85-2574
The Decomposition Method in Stochastic Structural Dynamics
H. Benaroya, M. Rehak
Weidlinger Associates, New York, NY
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 266-281, 56 figs, 13 refs

KEY WORDS: Random vibrations, Frequency domain method

Linear, random differential equations are studied with the purpose of understanding the effects of parameter uncertainties on the random vibration of structures. A single degree-of-freedom oscillator with random (stationary) stiffness and input, and with deterministic, constant mass and damping is considered.

85-2575
An Iterative Procedure for Nonlinear Flutter Analysis
C.L. Lee
Texas Instruments Inc., Lewisville, TX
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 290-297, 13 figs, 5 tables, 21 refs

KEY WORDS: Flutter, Iteration, Frequency domain method

An iterative procedure in the frequency domain is presented for flutter analysis of large dynamic systems with multiple structural nonlinearities. The major components of the procedure are the describing function approach for system linearization, a structural dynamics modification method for shifting system mode shapes and frequencies, and a complex eigenvalue algorithm for solution of the flutter equation. The purpose of the procedure is to achieve alignment of the oscillator amplitude in each nonlinear spring with the describing function of stiffness before computing the final stability characteristics. The result is a system tuned to the flutter frequency at the time of instability.

85-2576
Transient Aerodynamic Characteristics of a Two-Dimensional Airfoil During Stepwise Incidence Variation
Y. Aihara, H. Koyama, A. Murashige
University of Tokyo, Tokyo, Japan
J. Aircraft, 22 (8), pp 661-668 (Aug 1985) 13 figs, 14 refs

KEY WORDS: Airfoils, Aerodynamic Characteristics

The transient aerodynamic characteristics of a two-dimensional low-speed airfoil whose angle of attack is varied impulsively are discussed. The study is mainly an experimental one with observations made of the three dynamic loads, the static pressure distribution, and flow on the airfoil surface, following the airfoil motion. The changes in the characteristics and their aerodynamic causes are investigated in terms of the ultimate angle of attack and the rise of time.

85-2577
Viscous Effects on Transonic Airfoil Stability and Response
H.M. Berry, J.T. Batina, T.Y. Yang
Purdue University, West Lafayette, IN
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985 Orlando, FL, Spons. AIAA/ASME/ASCE/AHS, Part 2, pp 10-22, 13 figs, 4 tables, 20 refs

KEY WORDS: Airfoils, Aerodynamics loads, Stability, Viscosity effects, Flutter

Viscous effects on transonic airfoil stability and response are investigated using an integral boundary layer model coupled to the inviscid XTRAN2L transonic airloads required for stability analysis including viscous effects. Unsteady transonic airloads required for stability analysis are computed using a pulse transfer-function analysis including viscous effects. The pulse analysis provides unsteady aerodynamic forces for a wide range of reduced frequency in a single flowfield computation. Nonlinear time-marching aeroelastic solutions are presented which show the effects of viscosity on airfoil response behavior and flutter.

MECHANICAL PROPERTIES

DAMPING

85-2578
Unconstrained Layer Damping and the Use of Modified PVA as a High Efficiency Lightweight Material
D.W. Tomkins
Gerard Thomas Co., Inc.
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Society of Automotive Engineers, Warrendale, PA, pp 53-59, 7 figs

KEY WORDS: Layered damping, Viscoelastic properties, Automobiles

A lightweight polymeric visco-elastic sheet material has been developed which exhibits excellent vibration damping performance when used as an unconstrained layer on sheet metal panels. Geiger plate decay rates of 26 dB/sec and have been meas-

ured. The sheet is flexible, non-toxic, and meets automotive and building flammability specifications.

85-2579
Dual Clearance Squeeze Film Damping for High Load Conditions
D.P. Fleming
Lewis Res. Ctr., Cleveland, OH
J. Tribology, Trans. ASME, 107 (2), pp 274-279 (Apr 1985) 8 figs, 9 refs

KEY WORDS: Squeeze film dampers

Squeeze film dampers are widely used to control vibrations in aircraft turbine engines and other rotating machinery. However, if shaft unbalance rises appreciably above the design value (e.g., due to turbine blade loss), a conventional squeeze film will be overloaded, and will no longer be effective in controlling vibration amplitudes and bearing forces.

85-2580
Forced Vibration of a Damped Combined Linear System
L.A. Bergman, J.W. Nicholson
Univ. of Illinois, Urbana-Champaign, IL
J. Vib., Acoust., Stress Rel. Des., Trans. ASME, 107 (3), pp 275-281 (July 1985) 8 figs, 4 tables, 14 refs

KEY WORDS: Damped structures, Linear systems, Forced vibration

A new and general method for determining the exact undamped natural frequencies and natural modes of vibration, the orthogonality relation for the natural modes, and the response to arbitrary excitation for both damped and undamped combined linear systems, is given. The method, based upon Green's functions of the vibrating distributed subsystems, is demonstrated for a multiplicity of linear oscillators connected to a simple beam.

85-2581
Damping Synthesis Using Complex Substructure Modes and a Hermitian System Representation
J.-G. Beliveau, Y. Soucy
Universite de Sherbrooke, Sherbrooke (Quebec) Canada
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando FL, spons. AIAA/ASME/-ASCE/AHS, Part 2, pp 581-586, 1 fig, 4 tables, 12 refs

KEY WORDS: Modal damping, Modal synthesis, Mode shapes, Natural frequencies

Modal synthesis techniques have long been used to evaluate the natural frequencies and mode shapes of systems for which modal characteristics of the various components have been determined, either experimentally or numerically. Little attention has, been given in the prediction of damping levels of the total structure from damping information obtained experimentally, usually in the form of modal damping ratios and complex or real mode shapes. The purpose of this note is to present such a method, to demonstrate its use on a simple example, and to discuss two numerical aspects related to its numerical implementation.

85-2582
An Upper Hessenberg Sparce Matrix Algorithm for Modal Identification on Minicomputers
S.R. Ibrahim
Old Dominion University, Norfolk, Virginia
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, FL, Spons. AIAA/ASME/-ASCE/AHS, Part 2, pp 664-672, 2 tables, 44 refs

KEY WORDS: Modal analysis, Time domain method, Damping coefficients

The time domain identification problem is reduced to an eigenvalue problem of a sparse upper Hessenberg matrix. Such a matrix has only a number of elements equal to its order (one column); subdiagonal elements of unity and all the other remaining elements are zeros.

85-2583
Electronic Damping Techniques and Active Vibration Control
S. Hanagud, M.W. Obal, M. Meyyappa
Georgia Institute of Technology, Atlanta, GA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando FL, Spons. AIAA/ASME/-ASCE/AHS, Part 2, pp 443-453, 6 figs, 8 tables, 18 refs

KEY WORDS: Active vibration control, Damping effects

A theory has been developed to quantitatively identify changes in a damping matrix of structural dynamic system when electronic damping is applied to the system. Electronic damping experiments were conducted on a cantilever beam under impact excitation conditions. Piezoceramic transducers were used as both sensors and rivers with a velocity feedback. The mass, stiffness and damping matrices of the cantilever beam before and after application of the electronic damping were identified by a parameter identification technique that is capable of considering general linear viscous damping matrices.

FATIGUE

85-2584
Effect of Load Variation on Surface Durability of Normalized Steel Roller
S. Oda, T. Koide, J. Ando
Tottori Univ., Koyama-cho, Tottori, Japan
Bull. JSME, 28 (239), pp 964-970 (May 1985) 19 figs, 12 refs

KEY WORDS: Mechanical components, Steel, Compaction equipment

The characteristics of surface durability of an S45C normalized steel roller under two-step loading conditions are discussed on the basis of Miner's rule.

85-2585
A Combined Method for Damage Tolerance Analysis
A.S. Kuo, J.L. Rudd
Fairchild Republic Co., Farmingdale, NY
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, FL, Spons. AIAA/ASME/-ASME/ASCE/AHS, Part 1, pp 41-52, 12 figs, 6 tables, 15 refs

KEY WORDS: Fatigue life, Crack propagation, Computer programs

A combined crack growth and initiation method was developed to improve the predictive accuracy of damage tolerance analysis. The continuing damage at a location adjacent to the primary damage is realistically treated with fatigue crack initiation analysis in lieu of the assumed continuing damage size and location as stipulated in military specification MIL-A 83444.

85-2586
Cumulative Damage and Fatigue Life Prediction
T.V. Kutt, M.P. Bieniek
Columbia University, New York, NY
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, FL, Spons. AIAA/ASME/-ASCE/AHS, Part 1, pp 53-61, 7 figs, 23 refs

KEY WORDS: Fatigue life, Crack propagation, Damage prediction, Metals,

A cumulative damage rule is proposed for fatigue of metals under variable stress-amplitude loading. The rule is nonlinear and takes into account the sequence of stress levels; i.e., high-to-low or low-to-high changes of stress amplitudes. To facilitate probabilistic estimates of safety of structural elements subjected to fatigue loading, a stochastic model of fatigue damage id developed. The mean value and the variance of the fatigue life of an element are determined in terms of the statistics of the material properties and of the load parameters.

EXPERIMENTATION

MEASUREMENT AND ANALYSIS

85-2587
Effects of Structural Modes on Vibratory Force Determination by the Pseudo Inverse Technique
J.A. Fabunmi
Univ. of Maryland, College Park, MD
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 573-580, 5 figs, 3 tables, 13 refs

KEY WORDS: Force prediction, Mode shapes, Modal analysis, Linear theories, Beams

The accuracy and effectiveness of the pseudo inverse technique as a means of determining the operating vibratory loads on a structural system can be severely undermined, by lack of proper consideration of the participation of the structural modes at the frequency of interest. Methods of linear algebra and modal analysis are used to establish the limitations of this technique with regards to the number of independent forces determinable at a given frequency, in relation to the number and significance of structural modes participating in the response at that frequency.

85-2588
Digital Data Analysis Techniques for Extraction of Slosh Model Parameters
J.F. Unruh, D.D. Kana, F.T. Dodge, T.A. Fey
Southwest Res. Inst., San Antonio, TX
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 682-690, 7 figs, 2 tables, 5 refs

KEY WORDS: Modal analysis, Sloshing

Modern digital acquisition and modal analysis procedures are applied to the slosh model parameter extraction problem with considerable success. After appropriate data conditioning to remove the tank rigid mass and liquid rigid mass from the spectral data, the slosh peaks are circle fit to obtain estimates of the pendulum's masses, damping, and pivot arm locations.

85-2589
Experimental Substructure Coupling with Rotational Coupling Coordinates
Yung-Tseng Chung, R.R. Craig, Jr.
Bell Helicopter, Textron, Inc., Fort Worth, TX
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 484-489, 6 figs, 2 tables, 8 refs

KEY WORDS: Modal analysis, Rotational mode shapes, Spline technique, Substructuring method

A substructure coupling method based on experimentally measured data, including rotational coupling coordinates, is presented. The required rotational displacements at the interface are determine from the measured translational mode shapes by cubic spline interpolation. Simulation study shows that rotational mode shapes can be predicted accurately by the cubic spline interpolation using fewer translational frequency response function measurements than would be required by the finite difference method.

85-2590
Using Experimental Modal Modeling Techniques to Investigate Steering Column Vibration and Idle Shake of a Passenger Car
S.L. Chiang
Ford Motor Co.
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Society of Automotive Engineers, Warrendale, PA, pp 309-327

KEY WORDS: Experimental modal analysis, Automobile steering columns

An experimental modal model of an early prototype car was constructed and validated against test results. The model was then used to suggest practical hardware modification alternatives which would shift the steering column resonant frequency away from idle range, and maintain a low steering column tip vibration within the 600-750 RPM idle range. This model was also used to evaluate the effectiveness of tuning radiator mounts to the overall vehicle idle quality.

85-2591

Using Modal Analysis, Modeling and Analytical Modifications to Aid in the Development of Automotive Structures

D. Hauersperger
Structural/Kinematics
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Soc. of Automotive Engineers, Warrendale, PA, pp 303-307, 4 figs, 4 refs

KEY WORDS: Modal analysis, Motor vehicles

Modal Analysis has been advanced to the point where it can enable the user to select an optimum set of modifications that solve a problem analytically. There are three phases to an analysis of this type. The test parameters must be determined, the measurements must be taken, and the modal model (parameter estimation) is created. The concerns, techniques, requirements, and assumptions often forgotten when using modal analysis to generate a model of a structure, are addressed.

85-2592

Component Mode Synthesis for Structures with General Stiffness, Damping and Mass Matrices

K. Kubomura
Beloit Manhattan Inc., Clarks Summit, PA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 337-340, 3 refs

KEY WORDS: Component mode synthesis, Stiffness coefficients, Damping coefficients, Mass matrices

The component mode synthesis method for substructures with general rectangular forms of damping, stiffness and mass matrices is developed. For the development of reduction transformation equations, three aspects are discussed: the use of substructure modes of any frequency range; three different types of modes (free-free, cantilever and hybrid); the use of first and second order approximations. In this paper the reduction transformation equations for the use of lower frequency complex free-free and cantilever modes are presented.

85-2593

Development of an FM Multiplexed Telemetry System for Obtaining Dynamic Data from Operating Tank Track

C.W. Rodman, H.C. Meacham
Battelle-Columbus Labs.
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Soc. of Automotive Engineers, Warrendale, PA, pp 7-11, 5 figs

KEY WORDS: Data recorders, Measurement techniques, Tracked vehicles, Tanks (combat vehicles)

A system using FM multiplexed radio telemetry was developed and built to provide a data link between operating tank track and the tank hull. Field tests of the system showed that attention to details of the design of the antenna and battery system were successful in avoiding analytical problems.

85-2594

Obtaining Data to Determine the Effectiveness of Noise Controls

R.J. Goff, T.M. Lloyd
Safety and Health Technology Ctr.
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985, Spons. Soc. of Automotive Engineers, Warrendale, PA, pp 13-18, 6 figs, 1 table

KEY WORDS: Data recorders, Noise measurement, Mining equipment

In developing retrofit noise controls for mobile mining equipment, it is critical to document their effectiveness. The techniques used in gathering and analyzing data are described and a specific example is presented.

85-2595
A Concurrent Processing Implementation for Structural Vibration Analysis
S.W. Bostic, R.E. Fulton
NASA Langley Res. Ctr., Hampton, VA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 566-572, 11 figs, 2 tables, 7 refs

KEY WORDS: Data processing, Natural frequencies, Mode shapes

A report on an investigation of a concurrent processing implementation of the inverse power method for obtaining vibration frequencies and mode shapes is presented, and its increase in computation speed relative to sequential computer implementation is assessed. Results are obtained for vibration test problems run on an eight-processor experimental computer.

85-2596
Optimization of an Electromechanical Signal Filter by Means of Holographic Interferometry (Optimierung eines elektromechanischen Signalfilters mittels holographischer Interferometrie)
P. Valenta, E. Schneider
Max-Planck-Institut fur Metallforschung, Stuttgart, Fed. Rep. Germany
Feinwerktech. u. Messtech., 93 (2), pp 67-69 (Mar 1985), 5 figs, 4 refs (In German)

KEY WORDS: Holographic techniques, Vibration measurement, Optimization, Measurement techniques

The use of vibration holography enables the amplitude distribution on the surface of a vibrating object to be rendered directly visible and measured. From this are derived numerous applications that can be utilized for industrial purposes. Vibration holography is used for recording the forms of natural vibration in components with complex geometry for optimization of components from vibration engineering aspects or for locating material faults. A report is given on the optimization of an electromechanical signal filter from vibration engineering aspects.

DYNAMIC TESTS

85-2597
New Acoustic Test Facilities of BMW
R. Eilker, N. Herzum, W. Keiner, A. Ulrich
BMW AG
Surface Vehicle Noise and Vibration Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Soc. of Automotive Engineers, Warrendale, PA, pp 283-292, 11 figs, 1 ref

KEY WORDS: Test facilities, Automobiles, Motorcycles

New test standards for noise measurements on passenger cars and motorcycles are introduced. Information is given on room conditions, machinery equipment, sound levels, frequency ranges and types of measurement. Reports on initial experience with these test facilities are presented.

85-2598
Exploratory Flutter Test in a Cryogenic Wind Tunnel
S.R. Cole
NASA Langley Res. Ctr., Hampton, VA 23665
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 426-434, 17 figs, 2 tables, 9 refs

KEY WORDS: Flutter, Wind-tunnel testing, Aircraft wings

An experimental study to explore the feasibility of conducting flutter tests in cryogenic wind tunnels was conducted. The model used consisted of a rigid wing with an integral, flexible beam support that was cantilever mounted from the tunnel wall.

85-2599
Multimode Instability Prediction Method
K.E. Kadrnka
Rockwell International, El Segundo, CA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/ASME/ASCE/AHS, Part 2, pp 435-442, 19 figs, 8 refs

KEY WORDS: Flutter, Prediction techniques

The Zimmerman - Weissenburger method for prediction of flutter onset speed based on flight testing at subcritical speeds has been applied exclusively to a combination of two vibration modes. This process may therefore ignore a great deal of important information contained in other modes and their combinations. An extension of this method to incorporate more modes using standard stability criteria is presented.

DIAGNOSTICS

85-2600
Diagnosis and Prognosis of Turbomachinery Vibrations
H. Ming Chen, S.B. Malanoski
Mechanical Technology, Inc., Latham, NY
Rev. Tec. Ing., Univ. Zulia, Vol. 6, Edicion Especial, pp 111-131 (1983), 20 figs, 2 tables, 22 refs

KEY WORDS: Diagnostic techniques, Turbomachinery

A discussion on rotating equipment vibration problems - their occurrence, diagnosis by analytical and experimental methods, and a look to the future in this area, is presented.

85-2601
Building an Expert System to Diagnose Noise in Automotive Engine Cooling Systems
S.E. Dourson, J.D. Joyce
General Motors Corp., Kettering, OH
Surface Vehicle Noise and Vib. Conf. Proc., Traverse City, MI, May 15-17, 1985. Spons. Society of Automotive Engineers, Warrendale, PA, pp 19-26, 6 refs

KEY WORDS: Diagnostic techniques, Computer programs, Noise source identification, Engine noise, Cooling systems

The experiences of building a computer consultant to diagnose sources of noise in engine cooling systems are described. The emphasis is on identifying appropriate parameters and writing rules to codify the knowledge.

MONITORING

85-2602
Monitoring the Status of a Mechanical Cable While in Operation by Means of the Acoustic Emission Method
P.A.A. Laura, J.R. Matthews
Inst. of Applied Mechanics, Puerto Belgrano Naval Base, 8111 Argentina
Ocean Engrg., 12 (3), pp 211-219 (1985), 5 figs, 6 refs

KEY WORDS: Monitoring techniques, Acoustic emission, Cables

A brief review of research into failure mechanisms of various cables and the acoustic emission signature of the various cables under simulated loading is presented. The development of a specific operational monitor for a towed cable system is given.

ANALYSIS AND DESIGN

ANALYTICAL METHODS

85-2603
A Finite Element Method for Synthesis of Acoustical Shapes
R.J. Bernhard
Ray W. Herrick Labs., Purdue Univ., West Lafayette, IN
J. Sound Vib., 98 (1), pp 55-65 (Jan 8, 1985), 4 figs, 4 tables, 8 refs

KEY WORDS: Finite element technique, Optimization, Design techniques, Geometric effects, Acoustic properties

Classical finite element procedures are not well suited to the development of optimal acoustical shapes. Typical procedures require a complete analysis of each candidate acoustical geometry in the search for an optimal shape. A method is presented for decomposing the original finite element matrices which may be multiplied by shape change parameters to develop a model of the revised geometry. The method is also used to synthesize the geometry required for desired acoustical behavior of a complicated coupled cavity system.

85-2604
Vibration Analysis by Substructure Synthesis Method (Part 4, Calculation of Residual Compliance Matrix)
M. Ookuma, A. Nagamatsu
Tokyo Inst. of Technology, Tokyo, Japan
Bull. JSME, 28 (239), pp 905-910 (May 1985), 1 table, 5 refs

KEY WORDS: Substructuring methods, Structural synthesis

A method is proposed for accurately calculating the residual compliance matrix of structures with free-free boundary condition. Algorithms of the usual method and the method proposed by the authors as well as Hansteen are given and numerical examples of a simple case are shown.

85-2605
On the Oscillatory Instability of Multiple-Parameter Systems
A.S. Atadan, K. Huseyin
Univ. of Waterloo, Waterloo, Ontario, Canada
Intl. J. Engrg. Sci., 23 (8), pp 857-873 (1985), 5 figs, 30 refs

KEY WORDS: Stability, Balancing techniques

The postcritical oscillatory behavior of an autonomous discrete system under the influence of two independent parameters is studied. Three distinct situations are identified and explored via the intrinsic harmonic balancing technique. The asymptotic equations of the behavior surface in parameter-amplitude space are derived explicitly.

85-2606
Simple Approximants for Complex Linear Systems
J.L. Bogdanoff, F. Kozin
Purdue Univ., West Lafayette, IN
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 218-223, 2 figs, 8 refs

KEY WORDS: Approximation methods

A method is described for constructing a sequence of approximate systems of increasing complexity that can be employed to estimate the response of a complex linear system. Details of the method are sketched, and an example is briefly described.

85-2607
Time Series Approximation of Unsteady Aerodynamics Including Pole Locations as Free Parameters
L.D. Peterson, E.F. Crawley
Massachusetts Inst. of Technology, Cambridge, MA
Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17,

1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 251-257, 8 figs, 2 tables, 11 refs

KEY WORDS: Approximation methods, Aerodynamic loads, Time series analysis method

An algorithm has been developed to find exponential time series approximations to unsteady aerodynamic data at discrete frequencies using a least squares fit. The method differs from previous methods in that the pole locations of the exponential series approximation are explicitly included in the search, and that the fit simultaneously minimizes the error in both the real and imaginary parts of the approximation. A Newton-Raphson search algorithm is used to find the minimum of the weighted square error in the parameter space of the approximation while constraining the poles to be in the left half plane.

85-2608

On the Identification of Self-Adjoint Distributed Systems Using Modal Filters

H. Baruh, L.M. Silverberg

Rutgers Univ., New Brunswick, NJ

Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 673-681, 9 figs, 3 tables, 15 refs

KEY WORDS: Continuous parameter method, Modal filters, Parameter identification techniques

A method is presented for the identification of external excitations acting on distributed-parameter systems and, for certain cases, the parameters contained in the equations of motion of the distributed system. By extracting the modal coordinates from the system output, and using these modal coordinates to identify the modal excitations acting on a number of modes, the actual external disturbances are synthesized. The effects of factors such as measurement noise and interpolation error are analyzed.

85-2609

Systematic Approach for Eigensensitivity Analysis

Shyi-Yaung Chen, Fu-Shang Wei

Kaman Aerospace Corp., Bloomfield, CT

Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 178-183, 10 refs

KEY WORDS: Eigenvalue problems, Stability, Flutter, System identification techniques

Based on the matrix decomposition and generalized inverse technique, a method for the determination of the sensitivity of the eigenvalues and eigenvectors of nth order eigensystem, with respect to system design parameters, has been developed. This method requires knowledge of only one eigenvalue and its associated right and left eigenvectors which, together with information from the matrix column and null space, will lead to the eigenvalue and eigenvector derivative of a physical problem, such as stability analysis, flutter analysis, and system identification. Two different approaches and numerical procedures are utilized.

85-2610

On the Design Derivatives of Eigenvalues and Eigenvectors for Distributed Parameter Systems

R. Reiss

Howard Univ., Washington, D.C.

Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 173-177, 9 refs

KEY WORDS: Eigenvalue problems, Continuous parameter method

Analytic expressions are obtained for the design derivatives of eigenvalues and eigenfunctions of self-adjoint linear distributed parameter system. Explicit treatment of boundary conditions is avoided by casting the eigenvalue equation into integral form. Results are expressed in terms of the linear operators defining the eigenvalue problem,

and are therefore quite general. Sufficiency conditions appropriate to structural optimization of eigenvalues are obtained.

85-2611

The h-Version and p-Version of the Finite Element Method and the Inclusion Principle

L. Meirovitch, J.K. Bennighof
Virginia Polytechnic Inst. and State Univ., Blacksburg, VA

Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 691-698, 5 figs, 14 refs

KEY WORDS: Eigenvalue problems, Finite element technique

In the classical Rayleigh-Ritz method, improvement in the computed eigenvalues can be obtained by increasing the number of terms in the series expansion. The matrices defining the discrete eigenvalue problem possess the embedding property, in the sense that the matrix A corresponding to n + 1 terms is obtained from the matrix B corresponding to n terms by adding one row and the corresponding column. The computed eigenvalues satisfy the inclusion principle, which states that the eigenvalues of A bracket the eigenvalues of B. This paper examines how the inclusion principle relates to various elements and refinement strategies in the finite element method.

MODELING TECHNIQUES

85-2612

The Finite Element Modeling of the Free Vibration of a Read/Write Head Floppy Disk System

J.K. Good, R.L. Lowery
Oklahoma State Univ., Stillwater, OK

J. Vib., Acoust., Stress Rel. Des., Trans. ASME, 107 (3), pp 329-333 (July 1985), 14 figs, 11 refs

KEY WORDS: Computer storage devices, Vibration control, Design techniques, Finite element techniques

The configuration of read/write head designs in floppy disk drive units is of importance as some designs witness vibration phenomena which lead to signal loss and excessive wearing of the disk media. This paper presents finite element modeling, and results of a read/write head floppy disk system in free vibration. The objective of this work is to determine the design parameters of read/write head support structure which will reduce vibration phenomena.

PARAMETER IDENTIFICATION

85-2613

Identifying Approximate Linear Models for Simple Nonlinear Systems

L.C. Horta, Jer-Nan Juang
NASA Langley Res. Ctr., Hampton, VA

Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/-ASME/ASCE/AHS, Part 2, pp 282-289, 6 figs, 2 tables, 8 refs

KEY WORDS: Parameter identification technique

The identification of approximate linear models from response data for certain nonlinear dynamic systems is addressed. Response characteristics for several typical nonlinear joints are analyzed mathematically and represented by series expansions. The parameters of the series expansion are then compared with the modal parameters of a linear model identified by the Eigensystem realization algorithm.

DESIGN TECHNIQUES

85-2614

Dynamic Condensation for Structural Redesign

Ki-Ook Kim
Automated Analysis Corp., Ann Arbor, MI

Structures, Structural Dynamics and Materials Conf., Proc. of 26th, held April 15-17, 1985, Orlando, Florida, spons. AIAA/ASME/ASCE/AHS, Part 2, pp 379-383, 4 figs, 6 tables, 6 refs

KEY WORDS: Design techniques, Dynamic condensation method, Structural modification techniques, Natural frequency, Mode shapes

A structural redesign method using dynamic condensation is presented for frequency and mode shape changes of undamped structural systems. The equilibrium equation of the perturbed system includes nonlinear perturbations from a baseline design which are solved in an iterative procedure. The physical degrees of freedom are divided into master and slave sets. The method is simple and effective.

COMPUTER PROGRAMS

85-2615
Software System for Fatigue Life Calculation
M. Hanke, B. Kurz
Motor Car Res. Inst., UVMV, Prague, Czechoslovakia
Vehicle Structures, Intl. Conf., IMechE., London, Conf. Pub. 1984-7, SAE-MEP 200, pp 109-113, 4 figs, 11 refs

KEY WORDS: Computer programs, Fatigue life

Three main groups of the known cumulative damage calculation procedures are included in the described new subsystem ZIVOT; i.e., LIFE being built as part of a software system SADKO for evaluation of the continuous analog signals represented digitally by means of A/D converters.

GENERAL TOPICS

CONFERENCE PROCEEDINGS

85-2616
Internoise 84. International Cooperation for Noise Control
Proc. Intl. Conf. on Noise Control Engrg., Honolulu, Hawaii, Dec. 3-5, 1984, 2 Vols.

KEY WORDS: Noise control, Proceedings

The papers in these volumes cover the entire field of noise control engineering. A number of papers on the physical aspects of environmental noise, especially community noise control are included. Several papers on the subject of sound intensity are also presented.

CRITERIA, STANDARDS AND SPECIFICATIONS

85-2617
MIL-STD-810D vs. MIL-STD-810C - A Detailed Summary and Comparison. Part II: Method 514
H. Caruso
J. Environ. Sci., 28 (3), pp 47-52 (May/June 1985), 5 tables

KEY WORDS: Standards, T sting techniques, Vibration testing

A side-by-side comparison of the significant features of MIL-STD-810D and MIL-STD-810C, environmental test methods and engineering guidelines is presented. Included are details related to general test tailoring policy and application, test environments, and test facilities.

USEFUL APPLICATIONS

85-2618
Vibration-Random Required
J.D. McGrath, W. Kindig
General Electric Co.
J. Environ. Sci., 28 (3), pp 36-40 (May/June 1985), 8 figs, 6 tables, 5 refs

KEY WORDS: Random vibrations, Screening, Testing techniques

An approach to hardware screening using random vibration as a stimulus is presented. The proposed techniques were developed to achieve a screening program that is cost effective and is supportable in dollar payoff with increased productivity. Cost savings are realized by avoiding the assignment of a costly combined environment facility to each product line and reducing the number of test cycles required in the screening process.

PERIODICALS SCANNED

ACTA MECHANICA
(Acta Mech.)
Springer-Verlag New York, Inc.
175 Fifth Ave.
New York, NY 10010

ACUSTICA
(Acustica)
S. Hirzel Verlag, Postfach 40
7000 Stuttgart 1
Fed. Rep. Germany

AERONAUTICAL JOURNAL
(Aeronaut. J.)
Royal Aeronautical Society
4 Hamilton Pl.
London W1V 0BQ, UK

AIAA JOURNAL
(AIAA J.)
American Institute of Aeronautics and Astronautics
1633 Broadway
New York, NY 10019

AMERICAN SOCIETY OF CIVIL ENGINEERS, PROCEEDINGS
(ASCE, Proc.)
ASCE
United Engineering Center
345 E. 47th St.
New York, NY 10017

JOURNAL OF ENGINEERING MECHANICS
(ASCE J. Engrg. Mech.)

JOURNAL OF STRUCTURAL ENGINEERING
(ASCE J. Struc. Engrg.)

AMERICAN SOCIETY OF LUBRICATION ENGINEERS, TRANSACTIONS
(ASLE, Trans.)
ASLE
838 Busse Highway
Park Ridge, IL 60068

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, TRANSACTIONS
(Trans. ASME)
ASME
United Engineering Center
345 E. 47th St.
New York, NY 10017

JOURNAL OF APPLIED MECHANICS
(J. Appl. Mech., Trans. ASME)

JOURNAL OF DYNAMIC SYSTEMS, MEASUREMENT AND CONTROL
(J. Dynam. Syst., Meas. Control, Trans. ASME)

JOURNAL OF ENERGY RESOURCES TECHNOLOGY
(J. Energy Resources Tech., Trans. ASME)

JOURNAL OF ENGINEERING FOR INDUSTRY
(J. Engrg. Indus., Trans. ASME)

JOURNAL OF ENGINEERING FOR GAS TURBINES AND POWER
(J. Engrg. Gas Turbines Power, Trans. ASME)

JOURNAL OF PRESSURE VESSEL TECHNOLOGY
(J. Pressure Vessel Tech., Trans. ASME)

JOURNAL OF TRIBOLOGY
(J. Trib., Trans. ASME)

JOURNAL OF VIBRATION, ACOUSTICS, STRESS, AND RELIABILITY IN DESIGN
(J. Vib., Acoust., Stress, Rel. Des., Trans. ASME)

APPLIED ACOUSTICS
(Appl. Acoust.)
Applied Science Publishers, Ltd.
Ripple Road,
Barking, Essex, UK

AUTOMOBILTECHNISCHE ZEITSCHRIFT
(Automobiltech. Z.)
Franckh'sche Verlagshandlung
Abteilung Technik
7000 Stuttgart 1
Pfizerstrasse 5-7
Fed. Rep. Germany

AUTOMOTIVE ENGINEER (UK)
(Auto. Engr. (UK))
Mechanical Engineering Publications Ltd.
P.O. Box 24
Northgate Ave., Bury St. Edmunds
Suffolk IP32 6BW, UK

AUTOMOTIVE ENGINEERING (SAE)
(Auto. Engrg. (SAE))
Society of Automotive Engineers, Inc.
400 Commonwealth Dr.
Warrendale, PA 15096

BALL BEARING JOURNAL (English Edition)
(Ball Bearing J.)
SKF (UK) Ltd.
Luton, Bedfordshire
LU3 3BL, UK

BROWN BOVERI REVIEW
(Brown Boveri Rev.)
Brown Boveri and Co., Ltd.
CH-5401, Baden, Switzerland

BULLETIN OF JAPAN SOCIETY OF MECHANICAL ENGINEERS
(Bull. JSME)
Japan Society of Mechanical Engineers
Sanshin Hokusei Bldg.
H-9 Yoyogi 2-chome Shibuya-ku
Tokyo 151, Japan

BULLETIN OF SEISMOLOGICAL SOCIETY OF AMERICA
(Bull. Seismol. Soc. America)
P.O. Box 826
Berkeley, CA 94705

CANADIAN JOURNAL OF CIVIL ENGINEERING
(Can. J. Civ. Engrg.)
National Research Council of Canada
Ottawa, Canada K1A 0R6

CHARTERED MECHANICAL ENGINEER
(Chart. Mech. Engr.)
Institution of Mechanical Engineers
P.O. Box 24
Northgate Ave., Bury St. Edmunds
Suffolk IP32 6BW, UK

CHINA SCIENCE AND TECHNOLOGY ABSTRACTS
(China Sci. Tech. Abstracts)
International Information Service Ltd.
P.O. Box 24683
ABD Post Office, Hong Kong

CIVIL ENGINEERING (NEW YORK)
(Civ. Engrg. (NY))
ASCE
United Engineering Center
345 E. 47th St.
New York, NY 10017

COMPRESSED AIR
(Compressed Air)
253 E. Washington Ave.
Washington, NJ 07882-2495

COMPUTERS AND STRUCTURES
(Computers Struc.)
Pergamon Press Inc.
Maxwell House, Fairview Park
Elmsford, NY 10523

COMPUTERS IN MECHANICAL ENGINEERING
(Computers Mech. Engrg.)
ASME
United Engineering Center
345 E. 47th St.
New York, NY 10017

DESIGN NEWS
(Des. News)
Cahners Publishing Co., Inc.
221 Columbus Ave.
Boston, MA 02116

DIESEL PROGRESS
(Diesel Prog.)
Diesel Progress
13555 Bishop's Ct.
Brookfield, WI 53035

EARTHQUAKE ENGINEERING AND STRUCTURAL DYNAMICS
(Earthquake Engrg. Struc. Dynam.)
John Wiley and Sons Ltd.
Baffins Lane
Chichester, Sussex PO19 1UD,
England

ELECTRONIC PRODUCTS
(Electronic Prod.)
Hearst Business Communications, Inc.
P.O. Box 730
Garden City, NY 11530

ENGINEERING STRUCTURES
(Engrg. Struc.)
IPC Science and Technology Press Ltd.
Westbury House
P.O. Box 63, Bury St.
Guildford, Surrey GU2 5BH, UK

EXPERIMENTAL MECHANICS
(Exptl. Mech.)
Society for Experimental Stress Analysis
14 Fairfield Dr.
Brookfield Center, CT 06805

EXPERIMENTAL TECHNIQUES
(Exptl. Tech.)
Society for Experimental Stress Analysis
14 Fairfield Dr.
Brookfield Center, CT 06805

FEINGERÄTETECHNIK
(Feingerätetechnik)
VEB Verlag Technik
Berlin,
German Dem. Rep.

FEINWERKTECHNIK UND MESSTECHNIK
(Feinwerktech. u. Messtech.)
Carl Hanser Verlag
Postfach 860420
D-8000 München 86
Fed. Rep. Germany

FORSCHUNG IM INGENIEURWESEN
(Forsch. Ingenieurwesen)
Verein Deutscher Ingenieur, GmbH
Postfach 1139, Graf-Recke Str. 84
4 Düsseldorf 1,
Fed. Rep. Germany

GUMMI ASBEST KUNSTOSTOFFE
(Gummi Asbest Kunstst.)
A.W. Gentner Verlag GmbH and Co. KG
Forstrasse 131, Postfach 688
7000 Stuttgart,
Fed. Rep. Germany

HEATING/PIPING/AIR CONDITIONING
(Heating/Piping/Air Cond.)
Circulation Dept.
614 Superior Ave. West
Cleveland, OH 44113

HIGH TECHNOLOGY
(High Tech.)
Subscription Service Dept.
P.O. Box 2528
Boulder, CO 80322

HYDRAULICS AND PNEUMATICS
(Hydraul. Pneumat.)
Penton/IPC, Inc.
614 Superior Ave. West
Cleveland, OH 44113

HYDROCARBON PROCESSING
(Hydrocarbon Processing)
Gulf Publishing Co.
P.O. Box 2608
Houston, TX 77001

IBM JOURNAL OF RESEARCH AND DEVELOPMENT
(IBM J. Res. Dev.)
International Business Machines Corp.
Armonk, NY 10504

INDUSTRIAL LUBRICATION AND TRIBOLOGY
(Indus. Lubric. Trib.)
Peterson Publishing Co. Ltd.
Peterson House, Northbank,
Berryhill Industrial Estate
Droitwich, Worcs WR9 9BL,
England

INGENIEUR-ARCHIV
(Ing.-Arch.)
Springer-Verlag New York, Inc.
44 Hartz Way
Secaucus, NJ 07094

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, PROCEEDINGS
(IEEE, Proc.)
IEEE
United Engineering Center
345 E. 47th St.
New York, NY 10017

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, TRANSACTIONS
(IEEE, Trans.)
445 Hoes Lane
Piscataway, NJ 08854

INDUSTRIAL ELECTRONICS
(Indus. Electronics)

INDUSTRY APPLICATIONS
(Indus. Applic.)

INSTRUMENTATION AND MEASUREMENT
(Instrum. Meas.)

POWER APPARATUS AND SYSTEMS
(Power Apparatus Syst.)

SONICS AND ULTRASONICS
(Sonics Ultrasonics)

VEHICULAR TECHNOLOGY
(Vehicular Tech.)

INSTITUTE OF MARINE ENGINEERS, TRANSACTIONS (TM)
(Inst. Marine Engr., Trans. (TM))
Institute of Marine Engineers
76 Mark Lane
London EC3R 7JN, UK

INSTITUTION OF MECHANICAL ENGINEERS, PROCEEDINGS, PART C: MECHANICAL ENGINEERING SCIENCE
(IMechE, Proc.)
Institution of Mechanical Engineers
1 Birdcage Walk, Westminster,
London SW1, UK

INSTRUMENT SOCIETY OF AMERICA, TRANSACTIONS
(ISA, Trans)
Instrument Society of America
67 Alexander Dr.
Research Triangle Park, NC
27709

INSTRUMENTATION TECHNOLOGY
(Instrum. Tech.)
Instrument Society of America
67 Alexander Dr.
P.O. Box 12277
Research Triangle Park, NC
27709

INTERNATIONAL JOURNAL OF CONTROL
(Intl. J. Control)
Taylor and Francis Ltd.
10-14 Macklin St.
London WC2B 5NF, UK

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCE
(Intl. J. Engrg. Sci.)
Pergamon Press Inc.
Maxwell House, Fairview Park
Elmsford, NY 10523

INTERNATIONAL JOURNAL OF FATIGUE
(Intl. J. Fatigue)
Butterworth Scientific Ltd.
Journals Div.
P.O. Box 63, Westbury House,
Bury St.
Guildford GU2 5BH, Surrey, UK

INTERNATIONAL JOURNAL OF IMPACT ENGINEERING
(Intl. J. Impact Engrg.)
Pergamon Press Inc.
Maxwell House, Fairview Park
Elmsford, NY 10523

INTERNATIONAL JOURNAL OF MACHINE TOOL DESIGN AND RESEARCH
(Intl. J. Mach. Tool Des. Res.)
Pergamon Press Inc.
Maxwell House, Fairview Park
Elmsford, NY 10523

INTERNATIONAL JOURNAL OF MECHANICAL SCIENCES
(Intl. J. Mech. Sci.)
Pergamon Press Inc.
Maxwell House, Fairview Park
Elmsford, NY 10523

INTERNATIONAL JOURNAL OF NONLINEAR MECHANICS
(Intl. J. Nonlin. Mech.)
Pergamon Press Inc.
Maxwell House, Fairview Park
Elmsford, NY 10523

INTERNATIONAL JOURNAL FOR NUMERICAL AND ANALYTICAL METHODS IN GEOMECHANICS
(Intl. J. Numer. Anal. Methods Geomech.)
John Wiley and Sons Ltd.
Baffins Lane
Chichester, Sussex PO19 1UD, England

INTERNATIONAL JOURNAL FOR NUMERICAL METHODS IN ENGINEERING
(Intl. J. Numer. Methods Engrg.)
John Wiley and Sons Ltd.
Baffins Lane
Chichester, Sussex PO19 1UD, England

INTERNATIONAL JOURNAL OF SOLIDS AND STRUCTURES
(Intl. J. Solids Struc.)
Pergamon Press Inc.
Maxwell House, Fairview Park
Elmsford, NY 10523

INTERNATIONAL JOURNAL OF VEHICLE DESIGN
(Intl. J. Vehicle Des.)
Inderscience Enterprises Ltd.
World Trade Center Building
110 Avenue Louis Casai
Case Postale 306
CH-1215 Geneva
Aeroport, Switzerland

ISRAEL JOURNAL OF TECHNOLOGY
(Israel J. Tech.)
Weizmann Science Press of Israel
Box 801
Jerusalem, Israel

JOURNAL OF THE ACOUSTICAL SOCIETY OF AMERICA
(J. Acoust. Soc. Amer.)
American Institute of Physics
335 E. 45th St.
New York, NY 10017

JOURNAL OF AIRCRAFT
(J. Aircraft)
American Institute of Aeronautics and Astronautics
1633 Broadway
New York, NY 10019

JOURNAL OF ENVIRONMENTAL SCIENCES
(J. Environ. Sci.)
Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

JOURNAL OF THE FRANKLIN INSTITUTE
(J. Franklin Inst.)
Pergamon Press Inc.
Maxwell House, Fairview Park
Elmsford, NY 10523

JOURNAL DE MÉCANIQUE THÉORIQUE ET APPLIQUÉE
(J. de Mécanique Théor. Appl.)
Gauthier-Villars
C.D.R. - Centrale des Revues
11, rue Gossin, 92543 Montrouge, Cedex, France

JOURNAL OF PETROLEUM TECHNOLOGY
(J. Pet. Tech.)
Society of Petroleum Engineers
6200 N. Central Expressway
Dallas, TX 75206

JOURNAL OF PHYSICS, E: SCIENTIFIC INSTRUMENTS
(J. Phys., E: Sci. Instrum.)
American Institute of Physics
335 E. 45th St.
New York, NY 10017

JOURNAL OF SHIP RESEARCH
(J. Ship Res.)
Society of Naval Architects and Marine Engineers
One World Trade Center
Suite 1369
New York, NY 10048

JOURNAL OF SOUND AND VIBRATION
(J. Sound Vib.)
Academic Press Inc.
111 Fifth Ave.
New York, NY 10003

JOURNAL OF SPACECRAFT AND ROCKETS
(J. Spacecraft Rockets)
American Institute of Aeronautics and Astronautics
1633 Broadway
New York, NY 10019

JOURNAL OF STRUCTURAL MECHANICS
(J. Struc. Mech.)
Marcel Dekker, Inc.
270 Madison Ave.
New York, NY 10016

KONSTRUKTION
(Konstruktion)
Springer-Verlag
3133 Connecticut Ave., N.W.,
Suite 712
Washington, DC 20008

LUBRICATION ENGINEERING
(Lubric. Engrg.)
American Society of Lubrication Engineers
838 Busse Highway
Park Ridge, IL 60068

MACHINE DESIGN
(Mach. Des.)
Penton/IPC, Inc.
Penton Plaza,
1111 Chester Ave.
Cleveland, OH 44114

MASCHINENBAUTECHNIK
(Maschinenbautech.)
VEB Verlag Technik
Oranienburger Str. 13/14
1020 Berlin,
German Dem. Rep.

MECCANICA
(Meccanica)
Pergamon Press Inc.
Maxwell House, Fairview Park
Elmsford, NY 10523

MECHANICAL ENGINEERING
(Mech. Engrg.)
American Society of Mechanical Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

MECHANICS RESEARCH COMMUNICATIONS
(Mech. Res. Comm.)
Pergamon Press Inc.
Maxwell House, Fairview Park
Elmsford, NY 10523

MECHANISM AND MACHINE THEORY
(Mech. Mach. Theory)
Pergamon Press Inc.
Maxwell House, Fairview Park
Elmsford, NY 10523

MICROTECNIC
(Microtecnic)
Agifa Verlag
Universitätstrasse 94
P.O. Box 257
CH-8033 Zürich, Switzerland

MTZ MOTORTECHNISCHE ZEITSCHRIFT
(MTZ Motortech. Z.)
Franckh'sche Verlagshandlung
Pfizerstrasse 5-7
7000 Stuttgart 1,
Fed. Rep. Germany

NAVAL ENGINEERS JOURNAL
(Naval Engr. J.)
American Society of Naval Engineers, Inc.
1012 14th St., N.W.
Suite 507, Continental Bldg.
Washington, DC 20005

NDT INTERNATIONAL
(NDT Intl.)
Butterworth Scientific Ltd.
Journals Div.
P.O. Box 63, Westbury House,
Bury St.
Guildford, Surrey GU2 5BH, UK

NOISE CONTROL ENGINEERING JOURNAL
(Noise Control Engrg. J.)
P.O. Box 2306, Arlington Branch
Poughkeepsie, NY 12603

NUCLEAR ENGINEERING AND DESIGN
(Nucl. Engrg. Des.)
North-Holland Publishing Co.
P.O. Box 1000 AC
Amsterdam, The Netherlands

OCEAN ENGINEERING
(Ocean Engrg.)
Pergamon Press Inc.
Maxwell House, Fairview Park
Elmsford, NY 10523

PAPER TECHNOLOGY AND INDUSTRY
(Paper Tech. Indus.)
3, Plough Place, Fetter Lane
London EC4A 1AL, UK

PLANT ENGINEERING
(Plant Engrg.)
Technical Publishing Co.
1301 S. Grove Ave.
Barrington, IL 60010

POWER
(Power)
P.O. Box 430
Hightstown, NJ 08520

POWER TRANSMISSION DESIGN
(Power Transm. Des.)
1111 Chester Ave.
Cleveland, OH 44114

QUARTERLY JOURNAL OF MECHANICS AND APPLIED MATHEMATICS
(Quart. J. Mech. Appl. Math.)
Wm. Dawson and Sons, Ltd.
Cannon House
Folkestone, Kent, UK

REVUE ROUMAINE DES SCIENCES TECHNIQUES, SERIE DE MECANIQUE APPLIQUEE
(Rev. Roumaine Sci. Tech., Mecanique Appl.)
Editions de l'Academie
de la Republique Socialiste de Roumaine
3 Bis Str., Gutenberg, Bucharest, Romania

REVIEW OF SCIENTIFIC INSTRUMENTS
(Rev. Scientific Instrum.)
American Institute of Physics
335 E. 45th St.
New York, NY 10017

SAE TECHNICAL LITERATURE ABSTRACTS
(SAE Tech. Lit. Abstracts)
Society of Automotive Engineers
400 Commonwealth Dr.
Warrendale, PA 15086

SCIENTIFIC AMERICAN
(Scientific American)
415 Madison Ave.
New York, NY 10017

SHOCK AND VIBRATION DIGEST
(Shock Vib. Dig.)
Shock and Vibration Information Center
Naval Research Laboratory, Code 5804
Washington, DC 20375

SIAM JOURNAL ON APPLIED MATHEMATICS
(SIAM J. Appl. Math.)
Society for Industrial and *Applied Mathematics*
1405 Architects Building
117 S. 17th St.
Philadelphia, PA 19103

SIEMENS RESEARCH AND DEVELOPMENT REPORTS
(Siemens Res. Dev. Repts.)
Springer-Verlag New York Inc.
175 Fifth Ave.
New York, NY 10010

STROJNICKY CASOPIS
(Strojnícky Časopis)
Redakcia Strojnickeho Časopisu
ČSAV aSAV
Ústav Mechaniky Strojov SAV
Bratislava-Patronka, Dúbravská cesta, ČSSR, Czechoslovakia

S/V, SOUND AND VIBRATION
(S/V, Sound Vib.)
Acoustic Publications, Inc.
27101 E. Oviatt Rd.
P.O. Box 40416
Bay Village, OH 44140

TAPPI JOURNAL
(Tappi J.)
Technical Association of the Pulp and Paper Industry
15 Technology Park South
Norcross, GA 30092

TECHNICAL REVIEW (B and K)
(Tech. Rev. (B and K)
Bruel and Kjaer
185 Forest St.
Marlborough, MA 01752

TECHNISCHE MITTEILUNGEN KRUPP, FORSCHUNGSBERICHTE
(Techn. Mitt. Krupp, Forschungsber.)
Krupp Gemeinschaftsbetriebe,
Fachbücherei, Postfach 10 19
52, D-4300 Essen 1,
Fed. Rep. Germany

TECHNISCHE MITTEILUNGEN KRUPP, WERKSBERICHTE
(Techn. Mitt. Krupp, Werksber.)
Krupp Gemeinschaftsbetriebe,
Fachbücherei, Postfach 10 19
52, D-4300 Essen 1,
Fed. Rep. Germany

TECHNISCHES MESSEN-TM
(Techn. Messen-TM)
R. Oldenbourg Verlag GmbH
Rosenheimer Strasse 145, 8000
München 80, Fed. Rep. Germany

TEST
(Test)
Mattingley Publishing Co., Inc.
61 Monmouth Rd.
Oakhurst, NJ 07755

TRIBOLOGY INTERNATIONAL
(Trib. Intl.)
Butterworth Scientific Ltd.
Journals Div.
P.O. Box 63, Westbury House,
Bury St.
Guildford, Surrey GU2 5BH, UK

TURBOMACHINERY INTERNATIONAL
(Turbomachinery Intl.)
270 Madison Ave.
New York, NY 10016

VDI BERICHTE
(VDI Ber.)
Verein Deutscher Ingenieur GmbH
Postfach 1139, Graf-Recke Str.
84, 4 Düsseldorf 1,
Fed. Rep. Germany

VDI FORSCHUNGSHEFT
(VDI Forsch.)
Verein Deutscher Ingenieur GmbH
Postfach 1139, Graf-Recke Str.
84, 4 Düsseldorf 1,
Fed. Rep. Germany

VDI ZEITSCHRIFT
(VDI Z.)
Verein Deutscher Ingenieur GmbH
Postfach 1139, Graf-Recke Str.
84, 4 Düsseldorf 1,
Fed. Rep. Germany

VEHICLE SYSTEM DYNAMICS
(Vehicle Syst. Dynam.)
Swets and Zeitlinger B.V.
Publishing Dept.
347 B, Heereweg, 2161 Ca Lisse,
The Netherlands

VERTICA
(Vertica)
Pergamon Press
Maxwell House, Fairview Park
Elmsford, NY 10523

VIBROTECHNIKA
(Vibrotechnika)
Kauno Polytechnikos Institutas
2 Donelaicio g-ve 17
233000 Kaunas,
Lithuanian SSR

WAVE MOTION
(Wave Motion)
Elsevier Science Publishers
Molenwerf 1, P.O. Box 1991
1000 BZ Amsterdam,
The Netherlands

WEAR
(Wear)
Elsevier-Sequoia S.A.
P.O. Box 851
1001 Lausanne 1,
Switzerland

ZEITSCHRIFT FUR ANGEWANDTE MATHEMATIK UND MECHANIK
(Z. angew. Math. Mech.)
Akademie Verlag GmbH
Liepziger Str. 3-4
108 Berlin,
German Dem. Rep.

ZEITSCHRIFT FUR FLUGWISSENSCHAFTEN UND WELTRAUMFORSCHUNG
(Zt. f. Flugwiss. u. Weltraumforsch.)
DFVLR
D-3300 Braunschweig
Flughafen, Postfach 3267,
Fed. Rep. Germany

SECONDARY PUBLICATIONS SCANNED

DISSERTATION ABSTRACTS INTERNATIONAL
(DA)
University Microfilms International
300 N. Zeeb Rd.
Ann Arbor, MI 48106

GOVERNMENT REPORTS ANNOUNCEMENTS AND INDEX
(GRA)
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Rd.
Springfield, VA 22161

PROCEEDINGS SCANNED

INTER-NOISE PROCEEDINGS, INTERNATIONAL CONFERENCE ON NOISE CONTROL ENGINEERING
(Inter-Noise)
Noise Control Foundation
P.O. Box 3469, Arlington Branch
Poughkeepsie, NY 12603

MACHINERY VIBRATION MONITORING AND ANALYSIS MEETING, PROCEEDINGS
(Mach. Vib. Monit. Anal., Proc.)
The Vibration Institute
101 W. 55th St., Suite 206
Clarendon Hills, IL 60514

NOISE CONTROL PROCEEDINGS, NATIONAL CONFERENCE ON NOISE CONTROL ENGINEERING
(Noise Control)
Noise Control Foundation
P.O. Box 3469, Arlington Branch
Poughkeepsie, NY 12603

THE SHOCK AND VIBRATION BULLETIN, UNITED STATES NAVAL RESEARCH LABORATORIES, ANNUAL PROCEEDINGS
(Shock Vib. Bull., U.S. Naval Res. Lab., Proc.)
Shock and Vibration Information Center
Naval Research Lab., Code 5804
Washington, DC 20375

TURBOMACHINERY SYMPOSIUM
(Turbomachinery Symp.)
Gas Turbine Labs.
Texas A and M University
College Station, TX 77843

ABSTRACT CATEGORIES

MECHANICAL SYSTEMS

Rotating Machines
Reciprocating Machines
Power Transmission Systems
Metal Working and Forming
Isolation and Absorption
Electromechanical Systems
Optical Systems
Materials Handling Equipment

STRUCTURAL SYSTEMS

Bridges
Buildings
Towers
Foundations
Underground Structures
Harbors and Dams
Roads and Tracks
Construction Equipment
Pressure Vessels
Power Plants
Off-shore Structures

VEHICLE SYSTEMS

Ground Vehicles
Ships
Aircraft
Missiles and Spacecraft

BIOLOGICAL SYSTEMS

Human
Animal

MECHANICAL COMPONENTS

Absorbers and Isolators
Springs
Tires and Wheels
Blades
Bearings
Belts
Gears
Clutches
Couplings
Fasteners
Linkages
Valves
Seals
Cams

STRUCTURAL COMPONENTS

Strings and Ropes
Cables
Bars and Rods
Beams
Cylinders
Columns
Frames and Arches
Membranes, Films, and Webs
Panels
Plates
Shells
Rings
Pipes and Tubes
Ducts
Building Components

ELECTRIC COMPONENTS

Controls (Switches, Circuit Breakers
Motors
Generators
Transformers
Relays
Electronic Components

DYNAMIC ENVIRONMENT

Acoustic Excitation
Shock Excitation
Vibration Excitation
Thermal Excitation

MECHANICAL PROPERTIES

Damping
Fatigue
Elasticity and Plasticity
Wave Propagation

EXPERIMENTATION

Measurement and Analysis
Dynamic Tests
Scaling and Modeling
Diagnostics
Balancing
Monitoring

ANALYSIS AND DESIGN

Analogs and Analog Computation
Analytical Methods
Modeling Techniques
Nonlinear Analysis
Numerical Methods
Statistical Methods
Parameter Identification
Mobility/Impedance Methods
Optimization Techniques
Design Techniques
Computer Programs

GENERAL TOPICS

Conference Proceedings
Tutorials and Reviews
Criteria, Standards, and Specifications
Bibliographies
Useful Applications

TECHNICAL NOTES

D.T. Horak
A Simplified Modeling and Computational Scheme for Manipulator Dynamics
J. Dynam. Syst., Meas. Control, Trans. ASME, 106 (4), pp 350-353 (Dec 1984), 4 figs, 6 refs

Chyi Hwang
Mixed Method of Routh and ISE Criterion Approaches for Reduced-Order Modeling of Continuous-Time Systems
J. Dynam. Syst., Meas. Control, Trans. ASME, 106 (4), pp 353-356 (Dec 1984), 2 figs, 1 table, 11 refs

D. Karnopp
Computer Simulation of Stick-Slip Friction in Mechanical Dynamic Systems
J. Dynam. Syst., Meas. Control, Trans. ASME, 107 (1), pp 100-103 (Mar 1985), 6 figs, 3 refs

R.B. Bhat, R. Subbiah, and T.S. Sankar
Dynamic Behavior of a Simple Rotor with Dissimilar Hydrodynamic Bearings by Modal Analysis
J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 107 (2), pp 267-269 (Apr 1985), 4 figs, 5 refs

P.M. Moretti
Fundamental Frequencies of U Tubes in U-Tube Bundles
J. Pressure Vessel Tech., Trans. ASME, 107 (2), pp 207-209 (May 1985), 3 figs, 13 refs

Y. Frostig and G. Rosenhouse
Modulation-Function Technique in Nonuniform Mechanical Systems
J. Appl. Mech., Trans. ASME, 52 (2), pp 479-483 (June 1985), 1 fig, 18 refs

A.T. Kirkpatrick, M.A. El-Masri, and J.F. Louis
Wave Motion in Liquid Films on Rotating Plates
J. Appl. Mech., Trans. ASME, 52 (2), pp 488-490 (June 1985), 4 figs, 5 refs

K.R. Korde
On Nonlinear Oscillation of Moving String
J. Appl. Mech., Trans. ASME, 52 (2), pp 493-494 (June 1985), 1 fig, 6 refs

S. Deutsch
Frequency-Dependent Damping as an Explanation for the Anomalous Resonance Characteristics of the Auditory Cochlea
Acustica, 57 (1), pp 40-44 (Jan 1985), 7 figs, 10 refs

W.T. Chu
Room Response Measurements in a Reverberation Chamber Containing a Rotating Diffuser
J. Acoust. Soc. Amer., 77 (3), pp 1252-1256 (Mar 1985), 7 figs, 8 refs

M.C. Junger
The Sound Field in a Finite Cylindrical Shell
J. Acoust. Soc. Amer., 77 (4), pp 1610-1612 (Apr 1985), 7 refs

J.F. Allard and B. Sieben
Measurements of Acoustic Impedance in a Free Field with Two Microphones and a Spectrum Analyzer
J. Acoustic Soc. Amer., 77 (4), pp 1617-1618 (Apr 1985), 3 figs, 10 refs

P.A.A. Laura
Comment on "Flutter of Orthotropic Panels in Supersonic Flow Using Affine Transformations"
AIAA J., 22 (4), p 574 (1984), 10 refs

J.A. Brandon
On the Theoretical Justification of Ibrahim's Method
AIAA J., 23 (5), pp 815-816 (May 1985), 5 refs

B.H.K. Lee
Determination of Subcritical Damping in CF-5 Flight Flutter Tests
J. Aircraft, 22 (1), pp 89-91 (Jan 1985), 3 figs, 3 refs

R.G. Melton
A Composite Model of Aircraft Noise
J. Aircraft, 22 (5), pp 443-444 (May 1985), 2 figs, 1 table, 3 refs

W.H. Lin
Comments on "Free Transverse Vibrations of Uniform Circular Plates and Membranes with Eccentric Holes"
J. Sound Vib., 93 (4), pp 585-587 (1984), 1 fig, 1 table, 4 refs

H. Er-Li
No Reciprocal Theorem for Dynamic Displacements
J. Sound Vib., 96 (2), pp 275-276 (Sept 22, 1984)

K.B. Bota and R.E. Mickens
Approximate Analytic Solutions for Singular Non-Linear Oscillators
J. Sound Vib., 96 (2), pp 277-279 (Sept 22, 1984), 6 refs

V. Ramamurti and P. Balasubramanian
Application of Potter's Method for Frequency Analysis
J. Sound Vib., 96 (4), pp 513-515 (Oct 22, 1984), 2 tables, 5 refs

N.W.M. Ko
Flow Behind Coaxial Cylinders Joined by a Tapered Section
J. Sound Vib., 96 (4), pp 516-520 (Oct 22, 1984), 6 figs, 2 refs

M.D. Wiggins-Grandison and R.E. Mickens
Exact Solutions of Non-Linear Unidirectional Wave Equations
J. Sound Vib., 97 (1), pp 165-166 (Nov 8, 1984), 6 refs

F.J. Fahy
Rapid Method for the Measurement of Sample Acoustic Impedance in a Standing Wave Tube
J. Sound Vib., 97 (1), pp 168-170 (Nov 8, 1984), 1 fig, 1 ref

T. Irie, G. Yamada, and Y. Muramoto
Natural Frequencies of In-Plane Vibration of Annular Plates
J. Sound Vib., 97 (1), pp 171-175 (Nov 8, 1984), 5 tables, 10 refs

P.A.A. Laura, J.C. Utjes, and G.S. Sarmiento
Comments on "Flexural Free Vibrations of Rectangular Plates with Complex Support Conditions"
J. Sound Vib., 97 (1), pp 176-178 (Nov 8, 1984), 2 tables, 9 refs

P.A.A. Laura, D.R. Avalos, and R. Carnicer
Fundamental Frequency of a Circular Membrane with a Semicircular Perturbation at the Boundary
J. Sound Vib., 97 (1), pp 179-180 (Nov 8, 1984), 1 fig, 1 table, 2 refs

G.V. Rao and K.K. Raju
On Improving Eigenvalue Accuracies in Finite Elelment Analysis
J. Sound Vib., 97 (3), pp 523-525 (Dec 8, 1984), 1 table, 3 refs

S.N. Rao and N. Ganesan
Influence of Unsymmetric Boundary Conditions on Vibrations of Tapered Plates
J. Sound Vib., 97 (3), pp 526-530 (Dec 8, 1984), 3 figs, 3 tables, 4 refs

J. Szopa
Sensitivity of Stochastic Systems to Initial Conditions
J. Sound Vib., 97 (4), pp 645-649 (Dec 22, 1984), 3 figs, 2 tables, 5 refs

P. Verniere de Irassar, G. Ficcadenti, and L.C. Nava
A Note on Transverse Vibrations of a Non-Homogeneous Cardioidal Membrane
J. Sound Vib., 97 (4), pp 650-652 (Dec 22, 1984), 2 figs, 1 table, 3 refs

E. Uchino and M. Ohta
General State Estimation Algorithm for Quantized Noisy Systems by Statistical Equivalent Linearization Method, with Special Reference to Room Acoustics
J. Sound Vib., 97 (4), pp 653-657 (Dec 22, 1984), 4 figs, 4 refs

T. Das and R. Sircar
Free Flexural Vibration of an Isosceles Right Angled Triangular Plate Resting on a Non-Linear Elastic Foundation, at Large Amplitude
J. Sound Vib., 97 (4), pp 658-661 (Dec 22, 1984), 3 figs, 3 refs

J.W. Nicholson and L.A. Bergman
On the Efficacy of the Modal Series Representation for the Green Functions of Vibrating Continuous Structures
J. Sound Vib., 98 (2), pp 299-304 (Jan 22, 1985), 1 table, 11 refs

A. Sestieri
Discretization Procedures for the Green Formulation of Structural-Acoustic Problems
J. Sound Vib., 98 (2), pp 305-308 (Jan 22, 1985), 1 fig, 5 refs

R.S. Langley
On the Conditional Distribution of Velocity for a Stochastic Process
J. Sound Vib., 98 (2), pp 309-311 (Jan 22, 1985), 1 ref

Y. Hirata
The Sound Pressure Response When the Play-Back Method is Used in a Reverberant Chamber
J. Sound Vib., 98 (4), pp 589-591 (Feb 22, 1985), 1 fig, 2 refs

H.M.E. Miedema
Annoyance Caused by Two Noise Sources
J. Sound Vib., 98 (4), pp 592-595 (Feb 22, 1985), 1 fig, 3 refs

P.J.T. Filippi and J. Piraux
Noise Sources Modeling and Identification
J. Sound Vib., 98 (4), pp 596-600 (Feb 22, 1985), 6 tables

A. Bianchi, D.R. Avalos, and P.A.A. Laura
A Note on Transverse Vibrations of Annular, Circular Plates of Rectangular Orthotropy
J. Sound Vib., 99 (1), pp 140-143 (Mar 8, 1985) 5 tables, 3 refs

V.H. Cortinez and P.A.A. Laura
Vibrations and Buckling of a Non-Uniform Beam Elastically Restrained Against Rotation at One End and with Concentrated Mass at the Other
J. Sound Vib., 99 (1), pp 144-148 (Mar 8, 1985) 2 figs, 4 tables, 6 refs

J.-C. Nissen, K. Popp, and B. Schmalhorst
Optimization of a Non-Linear Dynamic Vibration Absorber
J. Sound Vib., 99 (1), pp 149-154 (Mar 8, 1985) 6 figs, 1 table, 5 refs

I. Sahin and A. Aybar
A Survey on Semisubmersible Wind Loads
Ocean Engrg., 12 (3), pp 253-261 (1985) 1 table, 18 refs

J.S. Tomar and R. Jain
Thermal Effect on Frequencies of Coupled Vibrations of Pretwisted Rotating Beams
AIAA J., 23 (8), pp 1293-1296 (Aug 1985) 2 figs, 1 table, 11 refs

FEATURE ARTICLES

	ISSUE	PAGES
Watkinson, P.S. **Sound Intensity Measurement**	1	3-13
De, Sasadhar **The Effects of Seismic Waves**	2	3-32
Munjal, M.L. **Recent Advances in the Analysis of Exhaust Mufflers**	3	3-16
Reddy, J.N. **A Review of the Literature on Finite-Element Modeling of Laminated Composite Plates**	4	3-8
Abdulhadi, M.I. **Stiffness and Damping Coefficients of Rubber**	5	3-9
Rades, M. **Frequency Domain Experimental Modal Analysis Techniques**	6	3-15
Kelly, J.M. **Aseismic Base Isolation**	7	3-14
deSilva, C.W. **Computer-Automated Failure Prediction in Mechanical Systems under Dynamic Loading**	8	3-12
Adeli, H. and Sierakowski, R.L. **Impactor Interaction with Concrete Structures — Local Effects**	9	3-16
Jones, D.I.G **High Temperature Damping of Dynamic Systems**	10	3-5
Bert, C.W. **Research on Dynamic Behavior of Composite and Sandwich Plates — IV**	11	3-15
Laura, P.A.A. **Acoustic Emissions from Wire and Synthetic Ropes**	12	3-5

LITERATURE REVIEWS

	ISSUE	PAGES
Abrate, S. **Continuum Modeling of Latticed Structures**	1	15-21
Jones, S. **Recent Progress in the Dynamic Plastic Behavior of Structures. Part IV**	2	35-47
Lalanne, M. **Vibration Problems in Jet Engines**	3	19-24
Etsion, I. **Mechanical Face Seal Dynamics Update**	4	11-15
D'Angelo, III, C., Alvarado, N.T., Wang, K.W., and Mote, Jr., C.D **Current Research on Circular Saw and Band Saw Vibration and Stability**	5	11-23
Gopalan, T.V. and Nagabhushana, G.R. **Flexural Rigidity of Stranded Cables**	6	17-20
Johns, D.J. **Wind-Excited Behaviour of Structures IV**	7	17-34
Vaicaitis, R. **Noise Transmission into Propeller Aircraft**	8	15-20
Sathyamoorthy, M. **Recent Research in Nonlinear Analysis of Beams**	9	19-27
Reinhorn, A.M. and Manolis, G.D. **Current State of Knowledge on Structural Control**	10	7-16
Beards, C.F. **Damping in Structural Joints**	11	17-20
Long, D.F. and Arndt, R.E.A. **Recent Research on Turbulent Flow Noise Mechanisms**	12	7-15

BOOK REVIEWS

Ash, E.A. and Hills, C.R., Eds., Acoustical Imaging, Volume 12, Plenum Publishing Corp., New York, 1982; Reviewed by V.R. Miller, SVD, 17 (9), pp 29-30 (Sept 1985).

Belytschko, T. and Hughes, T., Eds., Computational Methods for Transient Analysis, Elsevier Science Publishers, New York, 1983; Reviewed by A.K. Noor, SVD, 17 (6), pp 21-23 (June 1985).

Berkhout, A.J., Seismic Migration. Imaging of Acoustic Energy by Wave Field Extrapolation. A Theoretical Aspect, Elsevier Scientific Publ., Amsterdam and New York, 1982; Reviewed by S.K. Datta, SVD, 17 (2), p 49 (Feb 1985).

Beranek, L.L., Ed., Noise Reduction, Robert E. Krieger Pub. Co., Inc., Melbourne, FL, 1980; Reviewed by V.R. Miller, SVD, 17 (7), p 35 (July 1985).

Bolotin, V.V., Random Vibrations of Elastic Systems, Martinus Nijhoff Publishers, The Hague, The Netherlands, 1984; Reviewed by R.A. Ibrahim, SVD, 17 (7), pp 37-39 (July 1985).

Borissov, M., Ed., Optical and Acoustic Waves in Solids — Modern Topics, World Scientific Pub. Co., 1983; Reviewed by V.R. Miller, SVD, 17 (7), pp 36-37 (July 1985).

Burdic, W.S., Underwater Acoustic System Analysis, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1984; Reviewed by V.R. Miller, SVD, 17 (9), p 30 (Sept 1985).

Chajes, A., Structural Analysis, Prentice Hall, Inc., Englewood Cliffs, NJ, 1983; Reviewed by H. Saunders, SVD, 17 (2), pp 51-52 (Feb 1985).

Chen, F.Y., Mechanics and Design of Cam Mechanisms, Pergamon Press, Inc., Elmsford, NY, 1982; Reviewed by C. Reinholtz, SVD, 17 (12), pp 18-19 (Dec 1985).

Chu, D.F.H., Ed., Modal Testing and Model Refinement, ASME, New York, 1983; Reviewed by H. Saunders, SVD, 17 (4), pp 18-19 (Apr 1985).

Collins, J.A., Failure of Materials in Mechanical Design, John Wiley and Sons, New York, 1981; Reviewed by S.E. Benzley, SVD, 17 (4), p 17 (Apr 1985).

Das, B.M., Fundamentals of Soil Dynamics, Elsevier Scientific Publ., Amsterdam and New York, 1983; Reviewed by S.K. Saxena, SVD, 17 (2), pp 48-49 (Feb 1985).

deSilva, C.W., Dynamic Testing and Seismic Qualification Practice, Lexington Books, D.C. Heath & Co., Lexington, MA; Reviewed by D.D. Kana, SVD, 17 (5), pp 24-25 (May 1985).

Doebelin, E.O., Measurement Systems — Application and Design, McGraw-Hill Book Co., New York, 3rd Edition, 1983; Reviewed by H. Saunders, SVD, 17 (6), pp 25-26 (June 1985).

Fielding, L.E., Handheld Calculator Programs for Rotating Equipment Design, McGraw-Hill Book Co., New York, NY, 1983; Reviewed by H. Saunders, SVD, 17 (11), pp 23-25 (Nov 1985).

Franke, M.E. and Drzewiecki, T.M., Eds., Fluid Transmission Line Dynamics, ASME, New York, 1983; Reviewed by M.Z. Lee, SVD, 17 (2), p 48 (Feb 1985).

Goldstein, H., Classical Mechanics, Addison-Wesley, Reading, MA, 1980; Reviewed by L.Y. Bahar, SVD, 17 (5), pp 26-27 (May 1985).

Hamming, R.W., Digital Filters, Prentice-Hall, Inc., Englewood Cliffs, NJ; Reviewed by H. Saunders, SVD, 17 (9), pp 28-29 (Sept 1985).

Jayatilaka, A. de S., Fracture of Engineering Brittle Materials, Applied Science Publishers, Ltd., London, 1979; Reviewed by K.E. Hofer, SVD, 17 (1), p 24 (Jan 1985).

Kane, T.R., Likins, P.W., and Levinson, D., Spacecraft Dynamics, McGraw-Hill, New York, 1983; Reviewed by L.Y. Bahar, SVD, 17 (5), p 25 (May 1985).

Kinsler, L.E., Frey, A.R., Coppens, A.B., and Sanders, J.V., Fundamentals of Acoustics, John Wiley and Sons, New York, NY, 1982; Reviewed by V.R. Miller, SVD, 17 (11), pp 21-22 (Nov 1985).

Kolousek, V., Pirner, M., Fischer, O., and Naprstek, J., Wind Effects on Civil Engineering Structures, Elsevier Scientific Publ., Amsterdam and New York, 1984; Reviewed by S.S. Chen, SVD, 17 (1), p 22 (Jan 1985).

Lalanne, M., Berthier, P., and Der Hagopian, J., Mechanical Vibrations for Engineers, John Wiley and Sons, New York, 1983; Reviewed by H.C. Pusey, SVD, 17 (2), pp 49-51 (Feb 1985).

Macinante, J.A., Seismic Mountings for Vibration Isolation, John Wiley and Sons, New York, 1984; Reviewed by H.C. Pusey, SVD, 17 (1), pp 22-24 (Jan 1985).

Matthews, J.R., Ed., Acoustic Emission, Gordon and Breach Science Publishers, New York, 1983; Reviewed by R.J. Peppin, SVD, 17 (5), pp 27-28 (May 1985).

Milne, P.H., Underwater Acoustic Positioning Systems, Gulf Publishing Co., Houston, TX, 1983; Reviewed by V.R. Miller, SVD, 17 (11), p 21 (Nov 1985).

Moody, F.J., Ed., Two Phase Flow and Waterhammer Loads in Vessels, Piping and Structural Systems, ASME, New York, NY, 1984; Reviewed by K.E. Hofer, SVD, 17 (12), p 16 (Dec 1985).

Noor, A. and Pilkey, W., Eds., State-of-the-Art Surveys on Finite Element Technology, ASME, New York, 1983; Reviewed by M.M. Hurwitz, SVD, 17 (4), p 16 (Apr 1985).

Paz, M., Structural Dynamics Theory and Computation, Van Nostrand Reinhold Co., New York, NY, 1985; Reviewed by R.A. Ibrahim, SVD, 17 (10), pp 17-18 (Oct 1985).

Perrone, N., Pilkey, W., and Pilkey, B., Eds., Structural Mechanics Software Series V, University Press of Virginia, Charlottesville, VA, 1985; Reviewed by M.M. Hurwitz, SVD, 17 (10), pp 20-21 (Oct 1985).

Ragulskis, K., Varanauskas, P., Lelinas, V., Bentkus, R., and Andriuskevicius, A., The Dynamics of Precise Tape Drives, Leidykla Mokslas, Vilnius, USSR, 1984 (In Russian); Reviewed by A. Longinow, SVD, 17 (12), pp 17-18 (Dec 1985).

Rasband, S.N., Dynamics, John Wiley and Sons, New York, NY, 1983; Reviewed by H. Saunders, SVD, 17 (11), pp 22-23 (Nov 1985).

Rosenberg, R.C. and Karnopp, D.C., Introduction to Physical System Dynamics, McGraw-Hill Book Co., New York, NY, 1983; Reviewed by A. Frank D'Souza, SVD, 17 (8), p 21 (Aug 1985).

Ross, C.T.F., Finite Element Programs for Axisymmetric Problems in Engineering, Halsted Press, Div. of John Wiley and Sons, New York, 1984; Reviewed by J.T. Oden, SVD, 17 (3), p 25 (March 1985).

Rossberg, K., A First Course in Analytical Dynamics, John Wiley & Sons, New York, NY, 1983; Reviewed by R.A. Ibrahim, SVD, 17 (10), pp 19-20 (Oct 1985).

Sabnis, G.M., Harris, H.G., White, R.N., and Mirza, M.S., Structural Modeling and Experimental Techniques, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1983; Reviewed by V.R. Miller, SVD, 17 (9), pp 30-31 (Sept 1985).

Sevik, M.M., Ed., Turbulence-Induced Vibrations and Noise of Structures, ASME, New York, NY, 1983; Reviewed by V.R. Miller, SVD, 17 (8), pp 22-23 (Aug 1985).

Shah, V.N. and Ma, D.C., Eds., Seismic Effects in PVP Components, ASME, New York, 1984; Reviewed by K.E. Hofer, SVD, 17 (7), pp 35-36 (July 1985).

Shih, C.F. and Gudas, J.P., Eds., "Elastic Plastic Fracture," Second Symposium Volume I: Inelastic Crack Analysis, ASTM, Philadelphia, PA, 1983; Reviewed by K.E. Hofer, SVD, 17 (3), pp 25-27 (March 1985).

Shih, C.F. and Gudas, J.P., Eds., "Elastic Plastic Fracture," Second Symposium Volume II: Fracture Resistance Curves and Engineering Applications, ASTM, Philadelphia, PA, 1983; Reviewed by K.E. Hofer, SVD, 17 (3), pp 27-30 (March 1985).

Society of Automotive Engineers, Aircraft Noise Handbook, SAE, Warrendale, PA, 1984; Reviewed by V.R. Miller, SVD, 17 (8), pp 23-24 (Aug 1985).

Stanomir, D., Electroacoustic Systems. Field, Radiation and Transduction, Editura Tehnica, Bucharest, Roumania, 1984; Reviewed by M. Rades, SVD, 17 (8), pp 21-22 (Aug 1985).

Stijgeren, E.V., Ed., Piping Engineering Today: Innovative Solutions through Analysis, Testing, and Experience, ASME, New York, NY, 1984; Reviewed by K.E. Hofer, SVD, 17 (12), pp 16-17 (Dec 1985).

Tustin, W. and Mercado, R., Random Vibration in Perspective, Tustin Institute of Technology, Santa Barbara, CA, 1984; Reviewed by H. Saunders, SVD, 17 (6), pp 23-25 (June 1985).

Urick, R.J., Principles of Underwater Sound, McGraw-Hill Book Co., New York, NY, 1983; Reviewed by V.R. Miller, SVD, 17 (10), p 21 (Oct 1985).

Weaver, H.J., Applications of Discrete and Continuous Fourier Analysis, John Wiley and Sons, New York, 1983; Reviewed by H. Saunders, SVD, 17 (4), pp 17-18 (Apr 1985).

Zinkham, R.E., Ed., Fracture Toughness of Weldments, ASME, New York, 1984; Reviewed by K.E. Hofer, SVD, 17 (6), p 21 (June 1985).

LIST OF REVIEWERS

Abrate, S.
Adams, Jr., M.L.
Agrawal, B.N.
Allaire, P.E.
Al-Mousawi, M.
Arndt, R.E.A.
Bahar, L.Y.
Baker, W.E.
Barrett, L.
Beards, C.F.
Beltzer, A.I.
Bernard, J.E.
Bert, C.W.
Blanks, H.S.
Broek, D.
Bucci, R.
Camras, M.
Caseiro, C.
Chang, C.H.
Chen, S.-s.
De, S.
deSilva, C.W.
DiMaggio, F.L.
Dökmeci, M.C.
Dubey, R.N.
Etsion, I.
Etter, P.C.
Ewins, D.J.
Flack, R.D.
France, D.
GangaRao, H.V.S.
Genin, J.
Gibson, R.F.
Ginsberg, J.H.
Gopalakrishnan, S.
Goranson, U.
Greif, R.
Griffin, M.J.
Gupta, A.D.
Halford, G.
Hertzberg, R.
Hofer, K.
Holmes, R.
Holzer, S.
Hundal, M.S.
Huseyin, K.
Ibrahim, R.A.
Ignaczak, J.
Iwatsubo, T.
Jaske, C.
Johns, D.J.
Jones, D.I.G.
Jones, N.
Kelly, J.M.
Kiger, S.A.
Krajcinovic, D.
Laflen, J.H.
Lalanne, M.
Landgraf, R.
Leis, B.N.
Leissa, A.
Longinow, A.
Malanoski, S.
Manolis, G.D.
Massoud, M.
Mazumdar, J.
Metwalli, S.M.
Miller, V.
Milsted, M.G.
Mindlin, H.
Mote, C.D.
Mulcahy, T.M.
Munjal, M.L.
Nakra, B.C.
Nicholson, D.
Peppin, R.J.
Platzer, M.F.
Plunkett, R.
Popplewell, N.
Rades, M.
Ramamurti, V.
Rao, D.K.
Rao, J.S.
Rao, S.S.
Reddy, J.N.
Reifsnider, K.
Roberts, J.B.
Romilly, N.
Rungta, R.
Sankar, T.S.
Sathyamoorthy, M.
Saunders, H.
Shapton, C.W.
Shetty, D.
Sierakowski, R.L.
Soltis, L.
Spanos, P.D.
Stadelbauer, D.
Ting, E.C.
To, C.W.S.
Tondl, A.
Triantafyllou, M.
Vaičaitis, R.
Watkinson, P.
Wittlin, G.

AUTHOR INDEX

- C -

- E -

- G -

- H -

- J -

- K -

- M -

- N -

- O -

- P -

- Q -

- T -

- U -

- V -

SUBJECT INDEX

Abstract Numbers:	1-192	193-444	445-652	653-864	865-1055	1056-1263	1264-1496	1497-1756	1757-2002	2003-2199	2200-2406	2407-2618
Volume 17 Issue:	1	2	3	4	5	6	7	8	9	10	11	12

- C -

Abstract Numbers:	1-192	193-444	445-652	653-864	865-1055	1056-1263	1264-1496	1497-1756	1757-2002	2003-2199	2200-2406	2407-2618
Volume 17												
Issue:	1	2	3	4	5	6	7	8	9	10	11	12

- D -

- E -

(continued)

Abstract Numbers:	1-192	193-444	445-662	663-864	865-1055	1056-1263	1264-1486	1487-1786	1787-2002	2003-2199	2200-2406	2407-2618
Volume 17												
Issue:	1	2	3	4	5	6	7	8	9	10	11	12

Abstract Numbers:	1-192	193-444	445-652	653-864	865-1055	1056-1263	1264-1496	1497-1786	1787-2002	2003-2199	2200-2406	2407-2618
Volume 17 Issue:	1	2	3	4	5	6	7	8	9	10	11	12

Abstract Numbers:	1-192	193-444	445-652	653-864	865-1055	1056-1263	1264-1496	1497-1756	1757-2002	2003-2199	2200-2406	2407-2618
Volume 17 Issue:	1	2	3	4	5	6	7	8	9	10	11	12

Abstract Numbers:	1-192	193-444	445-652	653-864	865-1055	1056-1263	1264-1496	1497-1756	1757-2002	2003-2199	2200-2406	2407-2618
Volume 17 Issue:	1	2	3	4	5	6	7	8	9	10	11	12

- I -

- N -

Abstract Numbers:	1-192	193-444	445-652	653-864	865-1055	1056-1263	1264-1496	1497-1756	1757-2002	2003-2199	2200-2406	2407-2618
Volume 17 Issue:	1	2	3	4	5	6	7	8	9	10	11	12

Abstract Numbers:	1-192	193-444	445-652	653-864	865-1055	1056-1263	1264-1496	1497-1756	1757-2002	2003-2199	2200-2406	2407-2618
Volume 17 Issue:	1	2	3	4	5	6	7	8	9	10	11	12

Abstract Numbers:	1-192	193-444	445-652	653-864	865-1055	1056-1263	1264-1496	1497-1756	1757-2002	2003-2199	2200-2406	2407-2618
Volume 17 Issue:	1	2	3	4	5	6	7	8	9	10	11	12

Abstract Numbers:	1-192	193-444	445-652	653-864	865-1055	1056-1263	1264-1496	1497-1756	1757-2002	2003-2199	2200-2406	2407-2618
Volume 17 Issue:	1	2	3	4	5	6	7	8	9	10	11	12

Abstract Numbers:	1-192	193-444	445-652	653-864	865-1055	1056-1263	1264-1496	1497-1756	1757-2002	2003-2199	2200-2406	2407-2618
Volume 17 Issue:	1	2	3	4	5	6	7	8	9	10	11	12

- Y -

- Z -

CALENDAR

JANUARY

28-30 Reliability and Maintainability Symposium [ASME] Las Vegas, NV (ASME)

FEBRUARY

3-6 4th International Modal Analysis Conference [Union College] Los Angeles, CA (Ms. Rae D'Amelio, Union College, Wells House, Schenectady, NY 12308 - (518) 370-6288)

MARCH

5-7 Vibration Damping Workshop II [Flight Dynamics Laboratory of the Air Force Wright Aeronautical Labs.] Las Vegas, NV (Mrs. Melissa Arrajj, Administrative Chairman, Martin Marietta Denver Aerospace, P.O. Box 179, Mail Stop M0486, Denver, CO 80201 - (303) 977-8721)

24-27 Design Engineering Conference and Show [ASME] Chicago, IL (ASME)

APRIL

8-11 International Conference on Acoustics, Speech, and Signal Processing [Acoustical Society of Japan, IEEE ASSP Society, and Institute of Electronics and Communication Engineers of Japan] Tokyo, Japan (Hiroya Fujisaki, EE Department, Faculty of Engineering, University of Tokyo, Bunkyo-ku, Tokyo 113, Japan)

13-16 American Power Conference [ASME] Chicago, IL (ASME)

29-1 9th International Symposium on Ballistics [Royal Armament Research and Development Establishment] RMCS, Shrivenham, Wiltshire, UK (Mr. N. Griffiths, OBE, Head/XT Group, RARDE, Fort Halstead, Sevenoaks, Kent TN14 7BP, England)

MAY

12-16 Acoustical Society of America, Spring Meeting [ASA] Cleveland, OH (ASA Hqs.)

JUNE

3-6 Symposium and Exhibit on Noise Control [Hungarian Optical, Acoustical, and Cinematographic Society; National Environmental Protection Authority of Hungary] Szeged, Hungary (Mrs. Ildiko Baba, OPAKFI, Anker koz 1, 1061 Budapest, Hungary)

4-6 Machinery Vibration Monitoring and Analysis Meeting [Vibration Institute] Las Vegas, NV (Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254)

8-12 Symposium on Dynamic Behavior of Composite Materials, Components and Structures [Society for Experimental Mechanics] New Orleans, LA (R.F. Gibson, Mech. Engrg. Dept., University of Idaho, Moscow, ID 83843 - (208) 885-7432)

JULY

20-24 International Computers in Engineering Conference and Exhibition [ASME] Chicago, IL (ASME)

21-23 INTER-NOISE 86 [Institute of Noise Control Engineering] Cambridge, MA (Professor Richard H. Lyon, Chairman, INTER-NOISE 86, INTER-NOISE 86 Secretariat, MIT Special Events Office, Room 7-111, Cambridge, MA 02139)

24-31 12th International Congress on Acoustics, Toronto, Canada (12th ICA Secretariat, P.O. Box 123, Station Q, Toronto, Ontario, Canada M4T 2L7)

SEPTEMBER

14-17 International Conference on Rotordynamics [IFToMM and Japan Society of Mechanical Engineers] Tokyo, Japan (Japan Society of Mechanical Engineers, Sanshin Hokusei Bldg., 4-9, Yoyogi 2-chome, Shibuyak-ku, Tokyo, Japan)

22-25 World Congress on Computational Mechanics [International Association of Computational Mechanics] Austin, Texas (WCCM/TICOM, The University of Texas at Austin, Austin, TX 78712)

OCTOBER

5-8 Design Automation Conference [ASME] Columbus, OH (ASME)

5-8 Mechanisms Conference [ASME] Columbus, OH (ASME)

19-23 Power Generation Conference [ASME] Portland, OR (ASME)

20-22 Lubrication Conference [ASME] Pittsburgh, PA (ASME)

NOVEMBER

30-5 American Society of Mechanical Engineers, Winter Annual Meeting [ASME] San Francisco, CA (ASME)

CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AHS American Helicopter Society
1325 18 St. N.W.
Washington, D.C. 20036

AIAA American Institute of Aeronautics and Astronautics
1633 Broadway
New York, NY 10019

ASA Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE American Society of Civil Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

ASLE American Society of Lubrication Engineers
838 Busse Highway
Park Ridge, IL 60068

ASME American Society of Mechanical Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

ASTM American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

ICF International Congress on Fracture
Tohoku University
Sendai, Japan

IEEE Institute of Electrical and Electronics Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

IES Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

IMechE Institution of Mechanical Engineers
1 Birdcage Walk, Westminster
London SW1, UK

IFToMM International Federation for Theory of Machines and Mechanisms
U.S. Council for TMM
c/o Univ. Mass., Dept. ME
Amherst, MA 01002

INCE Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603

ISA Instrument Society of America
67 Alexander Dr.
Research Triangle Pk., NC 27709

SAE Society of Automotive Engineers
400 Commonwealth Dr.
Warrendale, PA 15096

SEE Society of Environmental Engineers
Owles Hall, Buntingford, Hertz.
SG9 9PL, England

SESA Society for Experimental Mechanics (formerly Society for Experimental Stress Analysis)
14 Fairfield Dr.
Brookfield Center, CT 06805

SNAME Society of Naval Architects and Marine Engineers
74 Trinity Pl.
New York, NY 10006

SPE Society of Petroleum Engineers
6200 N. Central Expressway
Dallas, TX 75206

SVIC Shock and Vibration Information Center
Naval Research Laboratory
Code 5804
Washington, D.C. 20375-5000

*U.S. GOVERNMENT PRINTING OFFICE: 1986-491-626:20015

PUBLICATION POLICY

Unsolicited articles are accepted for publication in the **Shock and Vibration Digest.** Feature articles should be tutorials and/or reviews of areas of interest to shock and vibration engineers. Literature review articles should provide a subjective critique/summary of papers, patents, proceedings, and reports of a pertinent topic in the shock and vibration field. A literature review should stress important recent technology. Only pertinent literature should be cited. Illustrations are encouraged. Detailed mathematical derivations are discouraged; rather, simple formulas representing results should be used. When complex formulas cannot be avoided, a functional form should be used so that readers will understand the interaction between parameters and variables.

Manuscripts must be typed (double-spaced) and figures attached. It is strongly recommended that line figures be rendered in ink or heavy pencil and neatly labeled. Photographs must be unscreened glossy black and white prints. The format for references shown in **Digest** articles is to be followed.

Manuscripts must begin with a brief abstract, or summary. Only material referred to in the text should be included in the list of References at the end of the article. References should be cited in text by consecutive numbers in brackets, as in the following example:

> Unfortunately, such information is often unreliable, particularly statistical data pertinent to a reliability assessment, as has been previously noted [1].
>
> Critical and certain related excitations were first applied to the problem of assessing system reliability almost a decade ago [2]. Since then, the variations that have been developed and practical applications that have been explored [3-7] indicate . . .

The format and style for the list of References at the end of the article are as follows:

-- each citation number as it appears in text (not in alphabetical order)

-- last name of author/editor followed by initials or first name

-- titles of articles within quotations, titles of books underlined

-- abbreviated title of journal in which article was published (see Periodicals Scanned list in January, June, and December issues)

-- volume, issue number, and pages for journals; publisher for books

-- year of publication in parentheses

A sample reference list is given below.

1. Platzer, M.F., "Transonic Blade Flutter -- A Survey," Shock Vib. Dig., 7 (7), pp 97-106 (July 1975).

2. Bisplinghoff, R.L., Ashley, H., and Halfman, R.L., Aeroelasticity, Addison-Wesley (1955).

3. Jones, W.P., (Ed.), "Manual on Aeroelasticity," Part II, Aerodynamic Aspects, Advisory Group Aeronaut. Res. Dev. (1962).

Articles for the **Digest** will be reviewed for technical content and edited for style and format. Before an article is submitted, the topic area should be cleared with the editors of the **Digest.** Literature review topics are assigned on a first come basis. Topics should be narrow and well-defined. Articles should be 3000 to 4000 words in length. For additional information on topics and editorial policies, please contact:

Milda Z. Tamulionis
Research Editor
Vibration Institute
101 W. 55th Street, Suite 206
Clarendon Hills, Illinois 60514